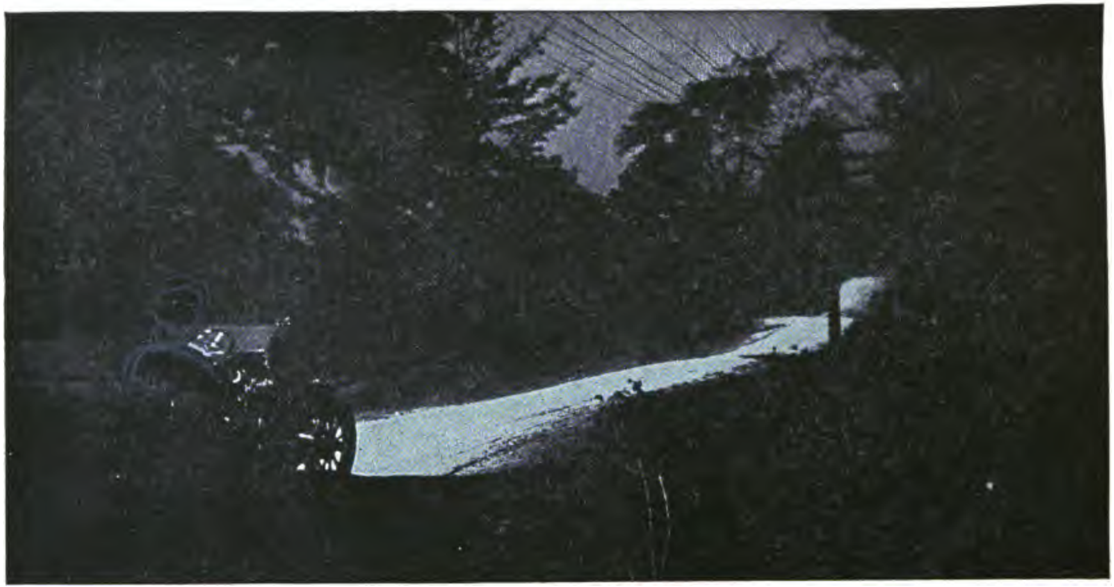

PLATE—ROAD ILLUMINATION BY ELECTRIC HEAD LIGHTS.

Usually 6 volt incandescent lamps are used. The filament is wound in a spiral so that it is practically a point, and with parabolic reflector a perfect focus is possible. With this possibility of focusing the lamp in the reflector there is provided either the projection of a powerful beam or pencil of light or a light with widely diffused rays. Reflectors with this adjustable focus features may be had suitable for installation in any of the standard existing headlights designed originally for gas burners. A sixteen candle power lamp consuming three amperes at six volts used in a headlight produces an illumination eighty feet distant, more than sufficient to enable one to read newspaper print. Comparative tests also show that a sixteen candle power lamp properly focused in the parabolic reflector throws twice as much light on a ten foot vertical circle fifty feet ahead as does the usual three-quarter foot acetylene burner in an ordinary ten inch gas headlight.

Booth, Charles E.

STARTING AND LIGHTING OF AUTOMOBILES

A PRACTICAL TREATISE ON SELF STARTERS WIRING AND LIGHTING AND THE STORAGE BATTERY.

INCLUDING

Matter relating to electricity, dynamos and motors, electric vehicles, mercury arc rectifiers, electric vaporizers, Vulcan electric gear shift, etc.

BY

GIDEON HARRIS *and Associates*

THEO. AUDEL & Co.
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PLATES

STARTERS AND LIGHTING SYSTEMS

In summing up the merits of the gas engine as a prime mover, there is one inherent defect that cannot be overlooked—the fact that, on account of the nature of its cycle of operation, it is not self-starting. It must be turned by some external force until the proper mixture has been drawn into the cylinder; compressed and ignited before it will start, unless perchance an unignited mixture be left in the cylinder and the piston be in the proper position; then by igniting the unburned charge the engine will usually start.

A difficulty sometimes experienced in cranking an engine by hand is to get the proper mixture, especially in the case of a large engine having a carburetter with no hand control of the primary air supply.

Because of the power required to turn the engine, it is usually turned too slow by hand to obtain enough suction, that is, pressure reduction in the mixing chamber, to draw in the proper amount of gasoline, and the mixture fails to ignite. This is especially the case if the car be standing on a hill so that the float level is lowered with respect to the nozzle; for in float feed carburetters, the fuel level being lower than the nozzle, an initial suction is required to bring the liquid to the nozzle and an additional pressure reduction, to cause it to discharge.

When the primary air supply is not adjustable, the usual procedure where trouble is experienced in obtaining the proper mixture, is to partially close the primary air passage (while cranking) either with the hand or by placing some obstruction in the passage. To overcome these difficulties and to relieve the operator of the physical effort and inconvenience of cranking, starters have been applied to engines and now form part of the regular equipment.

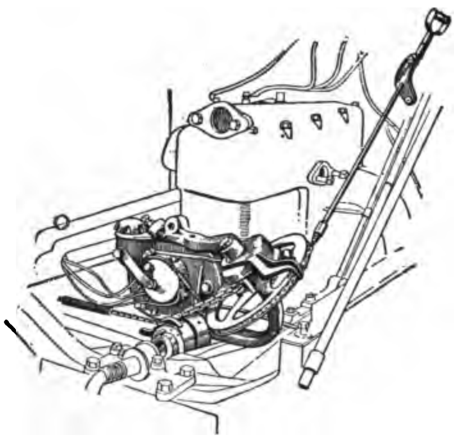


Fig. 1.—Boston mechanical starter designed especially for Ford car model T. The illustration shows the starter on car with fan and radiator temporarily removed.

The chief objection to these devices is the considerable additional mechanism to be cared for as well as the extra expense; but in the majority of cases these are more than offset by the elimination of hand cranking.

The delay of automobile manufacturers in developing starter systems and fitting them to their cars resulted in devices being placed on the market by individual designers, though crude as they were in the beginning, caused an immediate demand for starters by the public, which

was followed by efforts of the makers to supply their cars with starters. This naturally resulted in some very unsatisfactory rigs. The evidently immature applications of starting devices were noticeable on all sides. Such makeshift rigs naturally were more or less unsatisfactory and caused a prejudice which has not entirely disappeared, though there is no reason for a continuance of such prejudice, as the subsequent development has resulted in a number of starters that are highly satisfactory.

FIG. 2.—Interior of Ford car equipped with the Boston mechanical starter (made by the Automatic Appliance Co., Boston, Mass.); view looking toward dash and showing starter handle.

Classes of Starters.—The engine starting mechanism requires deep thought and engineering skill to properly apply it to an automobile, that is, making it an integral part of the car, preferably a part of the engine mechanism. The trend of design

is to reduce the added complication of the starting mechanism, —one of the chief objections against starters.

The various starting systems may be divided into the following classes:

1. Mechanical,
2. Compressed air,
3. Gas,
4. Electric.

Mechanical Starters.—What may be termed the purely mechanical means for starting is that of utilizing the energy

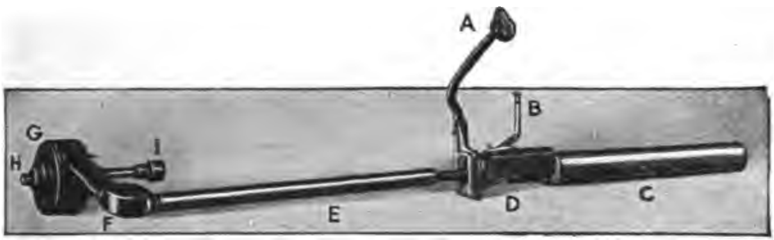


FIG. 3.—Knapp mechanical starter for Ford cars.

of a spring to crank the engine. Starters of this class consist of a powerful spring or springs contained in a casing about the size of a headlight and in some cases not unlike the latter in form.

The spring unit is so arranged that it is wound up by the engine in about twenty or thirty revolutions of the latter; an automatic device then releases the winding mechanism and the spring held by a brake or equivalent means. The tension of the spring is sufficient to overcome the compression of the engine and turn it several revolutions at a speed sufficient to insure ignition even by the magneto.

In case the engine fail to start, the spring may be rewound by hand by turning a small detachable hand crank; this acts, through a system of reducing gears, so that little effort is necessary. The engine may be turned by hand without interfering with the starter and, in case of back fire, the starter is automatically thrown out of gear.

FIG. 4.—Interior of Ford car showing control of Knapp mechanical starter. In operation, successive strokes of the foot lever A, compresses a spring to 350 lbs. pressure, which is released to start the engine by pressing with foot on trip lever B.

There is another class of spring starter, which does not receive its energy by being wound up by the engine. The winding is done by the operator from the seat by several strokes of a ratchet foot lever. When the spring has been wound, it is released by pressing a trip lever with the foot.

Volkman Mechanical Starter.—This is of the spring type and is illustrated in figs. 5 and 6. One end of the spring is hooked into the

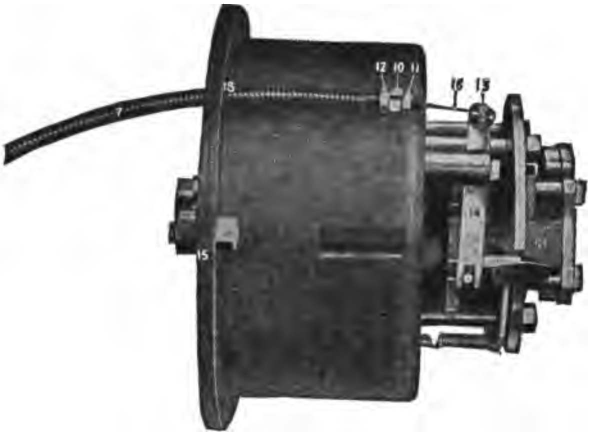
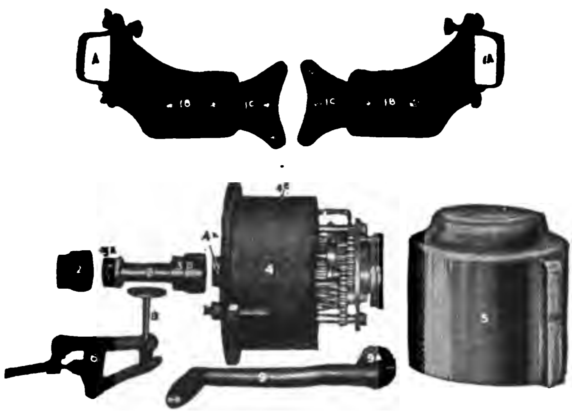


FIG. 5.—Assembly of Volkman mechanical starter. 10. post for releasing cable; 11, 12, lock nuts; 13, swivel on release lever; 14, release lever; 15, flange on spring case; 16, releasing cable; 17, spring holding clutch; 18, flange for brass sleeve.



FI 6.—Volkman mechanical starter partially disassembled. 1, universal brackets; 1a, clamps; 1b, right and left side members; 1c, right and left center members; 2, crank shaft coupling; 3, extension shaft; 3a and 3b, extension shaft couplings; 4, spring case; 4a, center shaft coupling; 4b, holding clutch rim; 4c, oil hole; 5, brass cover; 5a, channel for brass sleeve and releasing cable; 6, trip pedal bracket; 7, brass sleeve for releasing cable; 8, trip pedal; 9, crank; 9a, detachable collar for hand rewinding; 10, post for releasing cable; 11 and 12, lock nuts; 13, swivel on release lever; 14, release lever; 15, flange on spring case; 16, releasing cable; 17, spring holding clutch; 18, hole in flange for brass sleeve.

arbor upon which it is wound and the other end hooked into a steel case which covers the spring.

A pedal on the footboard connects with the starter, through the medium of a flexible steel cable.

Pressure on the pedal releases the spring, which turns the engine from six to twelve revolutions at high speed.

Through the center of the arbor and independent thereof, runs a steel shaft. This shaft extends beyond the rear of the springs and is fitted with a coupling which engages a coupling in the crank shaft of the engine, thus making the crank shaft and the starter shaft as one piece.

Keyed to starter shaft, so that it can move freely along it, is a sliding clutch, geared on each end. This clutch performs two functions:

When the starter is at rest, the springs being wound, the center shaft and sliding clutch revolve freely with any movement of the engine.

As soon, however, as the pedal used for tipping the starter is pressed down, the sliding clutch moves back and the gears on its back face engage corresponding gears on the face of the spring arbor, thus making the arbor, shaft and clutch as one piece.

The same movement releases the clutch which holds the spring power, allowing the arbor and shaft to be acted upon by the springs, thus turning the engine over.

In front of the center shaft, and held in position with posts attached to the spring case, is an immovable plate and bearing, in the center of which revolves the rewinding pinion.

The inner face of the rewinding pinion being geared to engage the gears in the face of the sliding clutch, and to the outer side of which is attached the holding clutch rim.

After the engine has started and the foot is removed from the trip pedal, the sliding clutch is pulled out of mesh with the spring arbor and pushed over, so that the gears on its opposite face engage with the rewinding pinion.

The springs are then rewound through a series of gears from the rewinding pinion to the spring arbor, the reduction being about one to fifteen.

When the spring arbor has made the required number of revolutions to rewind the springs to the same tension they were before being released, the sliding clutch is thrown out of mesh with the re-winding pinion and into neutral, by means of a Geneva gear, and the engine continues to run, without any of the starter being in motion except the center shaft and the sliding clutch.

The spring power is held by a clutch. A detachable crank is provided for hand rewinding in case the engine fail to start.

Compressed Air Starters.—Since on the modern automobile there is ample excess of power for running an air pump and room for a storage tank, the employment of compressed air as a form of energy for starting is a very desirable method, especially in view of the simplicity of the apparatus and the fact that the supply of air under pressure may be used for the inflation of tires.

With the large tires and high inflation pressures used, the elimination of hand pumping considerably enhances the value of compressed air starters.

FIG. 7.—Kellogg self-starting system; view of pump and distributer. It is mounted on the engine and driven from some exposed shaft, such as water pump or cam shaft. A clutch is contained within the distributer for engaging the pump and can be operated from a convenient place on the dashboard. The distributer is timed at half the engine speed, so when the engine stops, it is in such a position that it will allow the air from the tank to rush into the proper cylinder and to each cylinder consecutively. Admitting the air from the tank to the distributer is accomplished by the simple pressure of a button on the dash. Aside from the foot valve, a hand valve is also provided as an extra precaution when the engine is to be left over night; 150 lbs. of air is carried in the tank.

The various compressed air starters may be divided into two groups, according to whether the system includes,

1. A distributer, or
2. An air motor.

In the first mentioned class the power for starting is applied directly to the engine pistons, and in the other class to an air motor, which is geared to the engine.

There are two elements common to both classes: an air pump and tank for storing the compressed air.

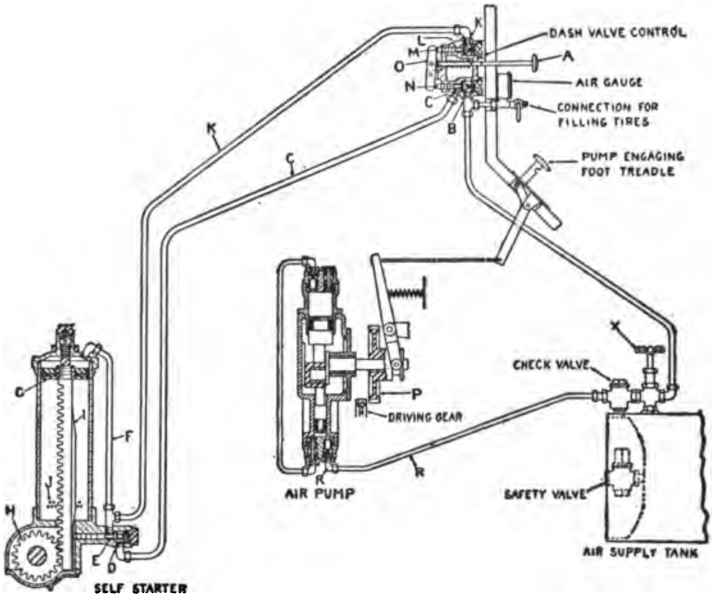
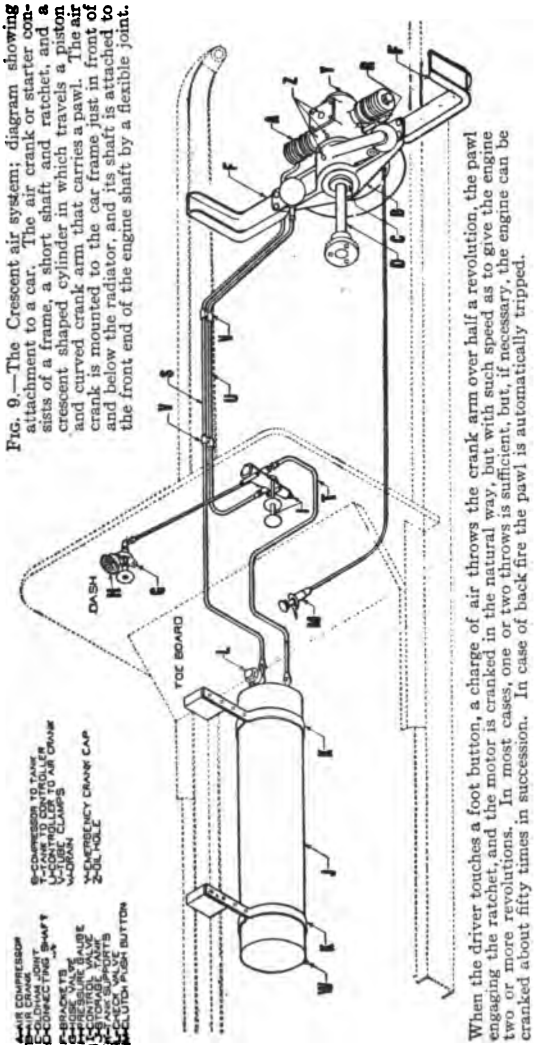


FIG. 8.—"Never miss" air starter; sectional diagram showing construction and operation. The starter is placed at the front of the car on crank shaft; dash valve on a portion of dash; and pump, which is a compound compresser, is driven by lay shaft of transmission, cam shaft, or geared from any moving shaft, running only at the will of the operator. The air tank is placed under the car. In operation, the driver presses down button A, which, due to lever O, raises valve N permitting air to pass from the supply tank through line C to D down to E of starter, through F to back of piston G, which causes rack I to revolve gear H. The latter in turn engages a clutch on shaft of engine, causing it to revolve with gear H as rack I passes over it. When the engine starts, a clutch (not shown) frees the starter. When button A is released, the rack I returns automatically ready for another start. The complete operation is done as quickly as the button is pressed and released. The air back of piston G is exhausted through pipe K, through orifice L, and also at the bottom of the stroke of the piston at holes J. Exhaust valve M and supply valve N, cannot be opened at the same time. Valve E in starter cuts supply from pipe F before piston reaches end of stroke, so that operator cannot waste air by continuing to press on button A. In case of back fire, the end of rack I is blank, which allows gear to H to revolve free. After back fire, rack I is returned automatically to position, ready to start. A gauge on dash shows air pressure. A connection for tire inflation is also provided. The pump is controlled by operator by means of foot treadle; in case he forget, a safety valve on tank is set to blow at 305 lbs.

FIG. 9.—The Crescent air system; diagram showing attachment to a car. The air crank or starter consists of a frame, a short shaft and ratchet, and a crescent shaped cylinder in which travels a piston and curved crank arm that carries a pawl. The air crank is mounted to the car frame just in front of and below the radiator, and its shaft is attached to the front end of the engine shaft by a flexible joint.



When the driver touches a foot button, a charge of air throws the crank arm over half a revolution, the pawl engaging the ratchet, and the motor is cranked in the natural way, but with such speed as to give the engine two or more revolutions. In most cases, one or two throws is sufficient, but, if necessary, the engine can be cranked about fifty times in succession. In case of back fire the pawl is automatically tripped.

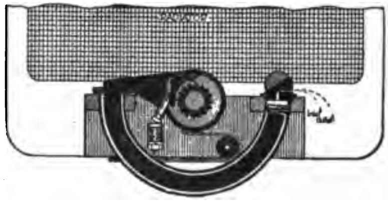
In starters of the first group, the compressed air passes from the tank to a distributer, which is a kind of rotary valve mounted on the engine and driven at half engine speed, with outlets to each cylinder.

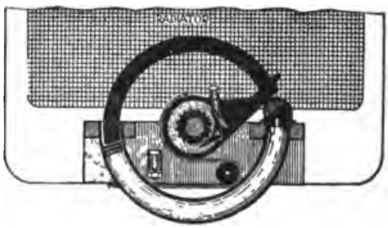
In operation a charge of compressed air is admitted to each cylinder in the firing sequence, that is, the distributer is timed in synchronism with the ignition.

In starters of the second group, the compressed air, instead of entering a distributer, passes to some form of compressed air motor which is used to start the engine.

The system employed on the Winton cars dispenses with the air pumps and is very simple. It consists of outlets tapped into the third and fourth cylinders of the six cylinder engine and connected by copper tubing to a pressure tank of the same material; a distributer mounted on the engine itself, and driven at half engine speed; a dash gauge registering to 200 lbs.; a starting button and a shut off valve at the tank to prevent leakage when the car is allowed to stand idle for several days.

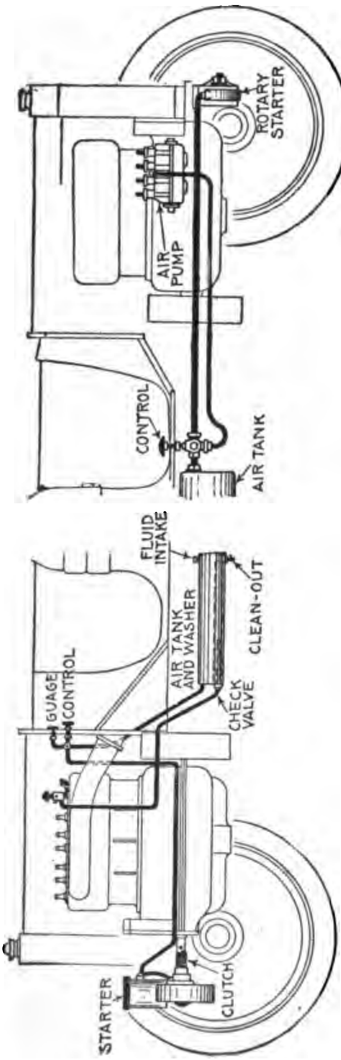
A portion of the energy of each firing stroke of the cylinders in question passes into the tank and is trapped by means of check valves at the cylinder outlets.





FIGS. 10 and 11.—Air crank of Crescent air system. Fig. 10.—Normal position of air crank; fig. 11, action of cresent air crank in cranking the engine. **To start engine:** set spark as for hand cranking; 2, set gas lever as for hand cranking; 3, operate priming wire, if car be so equipped. In cold weather use priming device; 4, press air crank foot button I downward once, firmly but **not too rapidly,** and remove foot immediately; 5, if motor fail to start, repeat No. 4, always permitting the air crank arm to return; 6, if engine do not start after third or fourth attempt, note if carburetter be flooded, or battery not working, or no gasoline, etc.; 7, avoid back firing of engine,—it places severe strains on the air crank; 8, *don't press air crank, push button I while the engine is running.* **To operate the compressor,** 1, engine must be running at a **moderate** speed, only; 2, press clutch foot button M downward quickly, permitting catch to engage; 3, release clutch foot button M when gauge shows desired air pressure,—250 lbs., *watch the gauge*; 4, do not engage compressor clutch at excessive speeds, **slow down;** 5, it is preferable to operate compressor while car is under motion; 6, compressor gives the best results at about twelve to fifteen miles per hour. **When tank is empty;** 1, press down clutch foot button M (see fig. 9) until catch engages; 2, set spark, as for hand cranking; 3, set gas lever as for hand cranking; 4, remove the cap Y from the front of compressor exposing hand crank dog; 5, insert hand crank, turning slowly, until compressor clutch engages; 6, operate priming wire if car be so equipped; 7, crank the engine by hand, emergency crank; 8, **don't** try to crank engine by pulling up on the air crank arm, you may injure your fingers; 9, after engine is in motion, replace cap Y on compressor, **drawing screws up tight;** 10, release clutch foot button M when gauge registers a pressure of 250 lbs.

NOTE—*Points relating to air starting*—**Compressor fails to pump:** Leaky valve,—dirt under seat; persistent leaky valve,—grind in; valve sticking,—caused by carbonized or gummy oil, or dirt; leaky piston,—rings sticking due to carbonized or gummy oil. Joints and cylinder heads, valve plugs, or valve screws not drawn up tightly; pipe line between compressor and tank leaking. **Air pressure does not hold**—by wiping joints with a soap solution, a possible leak can be located quickly; leaky joints,—either at hose valve G, controller I pressure gauge H, or tank connections. Also drain plug; check valve not seated,—dirt under same; controller valve not seated,—dirt under same; caps not drawn up tightly, either on check or control valves; hose valve stem not screwed down sufficiently or must be ground in.



FIGS. 12 and 13.—Two types of pneumatic starters in which an air turbine is used. Fig. 12 shows the system of the pneumatic rotary cranker, and fig. 13, the Thurber rotary cranker with four cylinder air pump.

The distributer is timed in accordance with the firing order of the engine, so that upon releasing pressure from the tank by depressing the starter foot button, it operates the same as a compressed air motor at a speed depending upon the tank pressure.

The ignition current being turned on, a few turns usually suffice to cause the engine to take up its own cycle of operations, as the speed is ample to draw a mixture from the carburetter quickly.

The charging system is entirely automatic, without the need of any controlling devices, as when the pressure in the tank reaches 200 lbs. to the sq. in., it equalizes that of which the cylinders are capable of producing and no further charging occurs until there is a drop in the tank pressure.

The Thurber rotary starter is one of the two cases in which the principle of the turbine is employed. This system operates by compressed air, furnished by the Kellogg four cylinder high pressure pump, which makes it possible to carry at all times 200 pounds air pressure.

The Thurber starter consists of a rotary cranking device, an air pump, an air tank, two pipes and one valve. To start the car equipped with the Thurber system, the driver simply presses down with his foot on the double acting valve: air is delivered by pipe to the starter, which spins the engine.

As soon as the engine starts, an automatic clutch disengages the starter and it remains idle until again used. The average consumption of air for starting the motor is very small, one tankful of air being

sufficient for a large number of starts. In one recent test a 40 horse power engine with the Thurber system gave 150 starts, it is claimed.

In addition to cranking the engine, the Thurber system furnishes the user with air for pumping up tires.

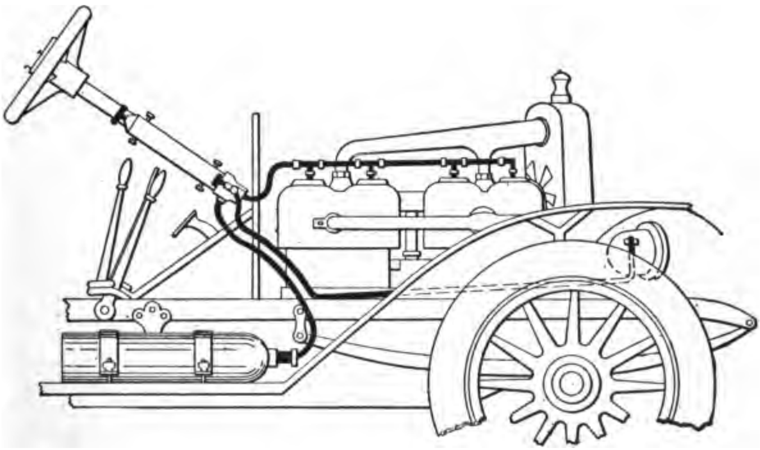


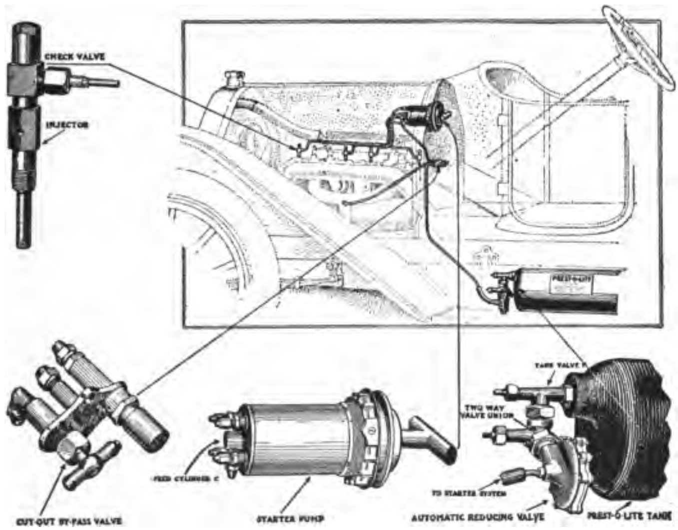
FIG. 14.—Niagara gas starter. As shown, an acetylene tank is connected with a compressor which is used for forcing the gas and air in proper proportions into the cylinders, check valves being provided to retain the charge. After the cylinders are thus primed, throwing on the switch starts the engine on the spark. In extreme cold weather the engine may be run on acetylene through the starter until it warms up.

Gas Starters.—The action of gas starters is to put a charge of gas into each of the cylinders, which, when ignited, gives an explosion in each cylinder. This is sufficient under normal conditions to start the engine. Under extreme conditions, such as a very cold day and a stiff carburetter, the operation may be repeated, if necessary.

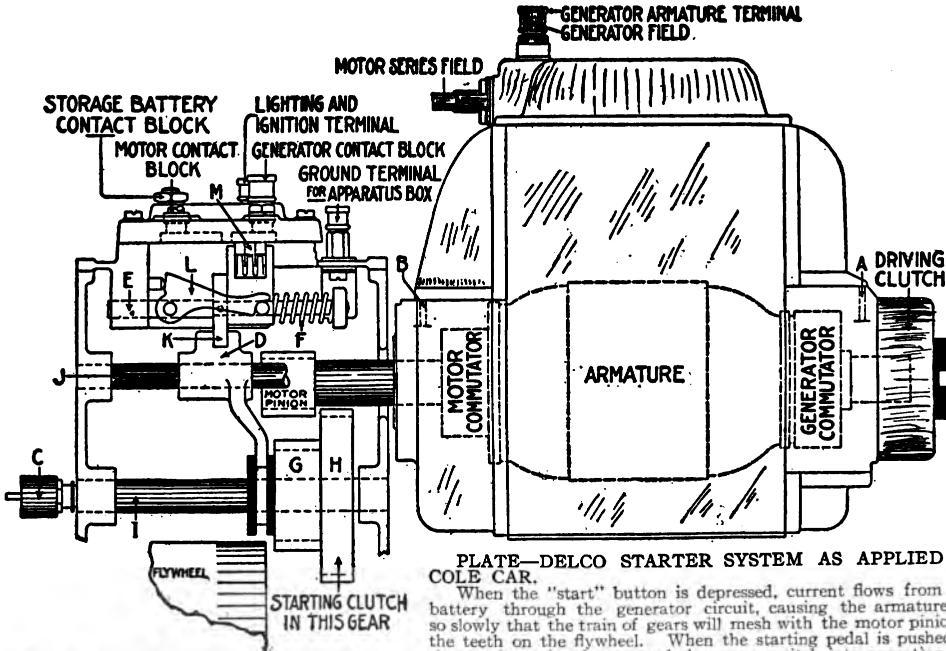
Most gas starters operate with acetylene, a charge of which is carried into the cylinder with each operation of the starter.

It is a harmless gas in itself and will only explode when mixed with air in proper proportions.

The essential conditions for the operation of a gas starter is "starting on the spark," that is, the engine must balance or stop in such position that when the current is turned on, a spark will occur in one of the cylinders to ignite the previously admitted charge.



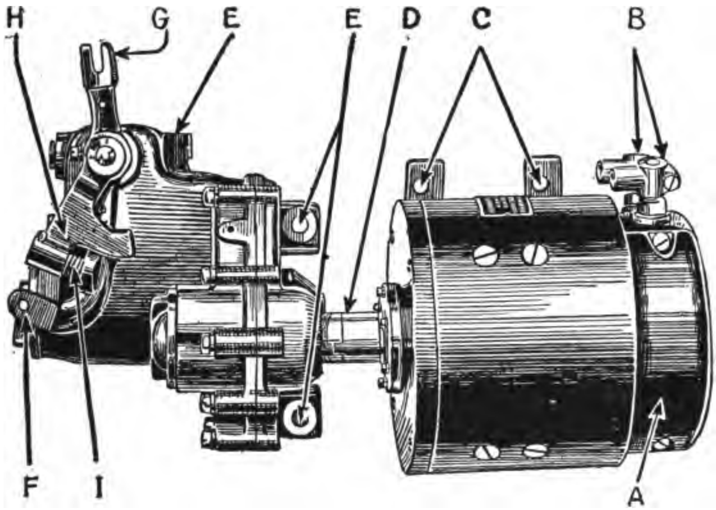
FIGS. 15 to 19.—Prest-O-Lite gas starter. The system comprises an automatic reducing valve, starter pump, distributer and cut out by-pass. The d.stinctive feature of the system is the reducing valve and by-pass valve. The reducing valve lowers the tank pressure, as it enters the starter system to a uniform pressure of two ounces. This allows the use of a pump, which means the injection of the charge regardless of the compression in the cylinder, and until the gas in the tank is exhausted. When the explosions of the injected charges are not sufficient to allow the engine to continue rotation, the by-pass prevents feeding acetylene under low pressure through the intake manifold. As soon as the engine warms and draws gas from the carburetter, the driver releases the by-pass valve and the flow from the tank to the intake manifold ceases. The only operation necessary in the use of a starter pump is a simple out and in stroke, by means of which the gas is first drawn into the pump, then forced by compression into the firing chambers of the engine. The acetylene is forced into the cylinders through injectors, which are located in any opening above the piston travel, usually the priming cup opening, either through the cylinder wall or valve cap. **To operate the starter,** *the driver first opens the cut out valve; then gives one or two strokes of the pump, and presses the button and the engine starts on the spark. After starting the cut out valve is closed.*



PLATE—DELCO STARTER SYSTEM AS APPLIED TO THE COLE CAR.

When the "start" button is depressed, current flows from the storage battery through the generator circuit, causing the armature to rotate so slowly that the train of gears will mesh with the motor pinion and with the teeth on the flywheel. When the starting pedal is pushed forward it throws the train of gears and the motor switch into operation.

As the starting pedal is depressed it causes the shifting yoke, D, which is connected to the switch operating rod, E, to compress the coiled spring, F, and at the same time causes the pair of gears, G and H, to slide along and revolve upon the clutch shaft, I. Gear H meshes with the motor pinion as the shifting yoke travels along on the rod, J. When the starting pedal nears its limit of travel, the collar K, trips the latch, L, which holds the contact block, M, in the forward position. The pressure of the coiled spring, F, snaps the contact block, M, in the rear position, permitting the current from the storage battery to flow through the motor windings and crank over the engine. It will be noted that the sliding block, M, does not change its position until the pair of gears on the clutch shaft, I, are fully meshed.



PLATE—REMY STARTING SYSTEM AS APPLIED TO THE MITCHELL CAR.

The complete system comprises the motor, reduction gears, switch and battery. The reduction gears give a velocity ratio of 25 revolutions of motor to 1 of engine. One gear is fitted with an over running clutch.

How the System Operates—When starter pedal is pressed down lever F is brought forward carrying with it lever H which moves small gear in mesh with main starter gear at the forward end of the transmission, at the same time the top of the lever marked G moves back, the switch making a contact allowing the current from the storage battery to flow through the motor, through reduction gears, the motor now spins the engine.

If the starting gears do not mesh, the lever H remains stationary, the pressure on the starter pedal compresses the small spring I allowing the top of the lever marked G to move back the switch until contact is made, the motor then begins to revolve and the tension of the spring I snaps the small gear in mesh with the main starting gear.

General Instructions—The closing of the starting switch completes the circuit between the battery and the motor, and puts the starter in operation.

If the motor do not revolve when starter pedal is pushed completely down, release starter pedal at once and ascertain if all connections be tight and secure, inspect battery and switch.

If the motor turn the engine over very slowly it is evident that the battery is weak or engine stiff, make investigation.

If it be impossible to push starter pedal down full distance, small gear does not mesh with main starter gear and does not allow switch to move back far enough to make a contact.

If motor revolve but engine do not turn over, over-running or free clutch is not operating properly. Release starter pedal at once and again press down. If clutch still refuse to operate properly it is perhaps due to it either being clogged up with grease or dirt and reduction gear case should be flushed out with kerosene.

If the motor be turning the engine over at a reasonable cranking speed and the engine do not fire, remember that the motor is performing its duty, so do not let the motor continue to crank the engine longer than necessary as a needless drain is placed on battery. If engine do not fire, it is evident that trouble is confined to carburetter or ignition.

Should the starter fail due to the engine stopping on dead center, it is only necessary to make one-quarter turn with the crank and then start on the spark. The general use of the acetylene tank and the ease and promptness with which it may be refilled, makes the use of acetylene desirable for gas starters.

Electric Starters.—The employment of electricity for starting has the advantage of also supplying current for lighting

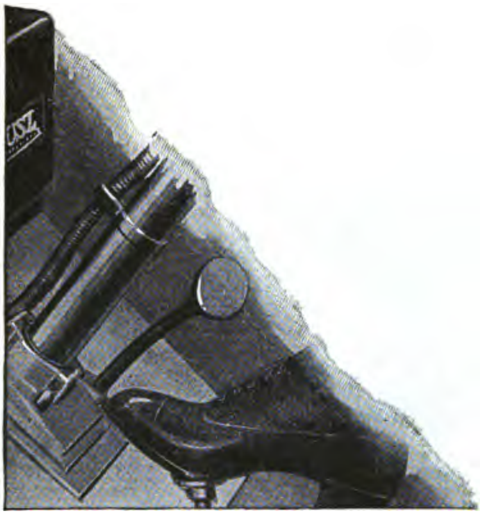


FIG. 21.—Footboard of auto showing U. S. L. starter button.

and ignition as well, and this has led to the development of systems involving various combinations. It would seem, therefore, that electricity would be universally used for starters, save for the fact that there are some objections, such as high cost, maintenance, and the considerable mechanism necessary, that offset more or less the advantages accruing from its threefold uses.

There are numerous electric starting systems, and they may be classified according to the methods of obtaining current for starting and ignition, and the power element of the starter, as:

1. One unit systems;
2. Two unit systems;
3. Three unit systems.

These several systems comprise respectively:

1. A motor-dynamo;
2. A motor-dynamo and separate magneto;*
3. A motor, a dynamo, and magneto all separate.

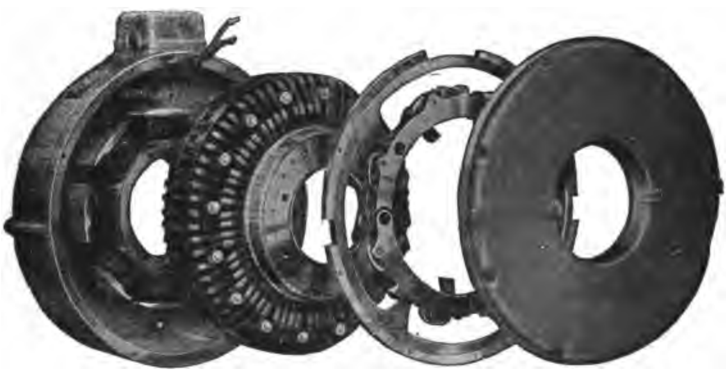
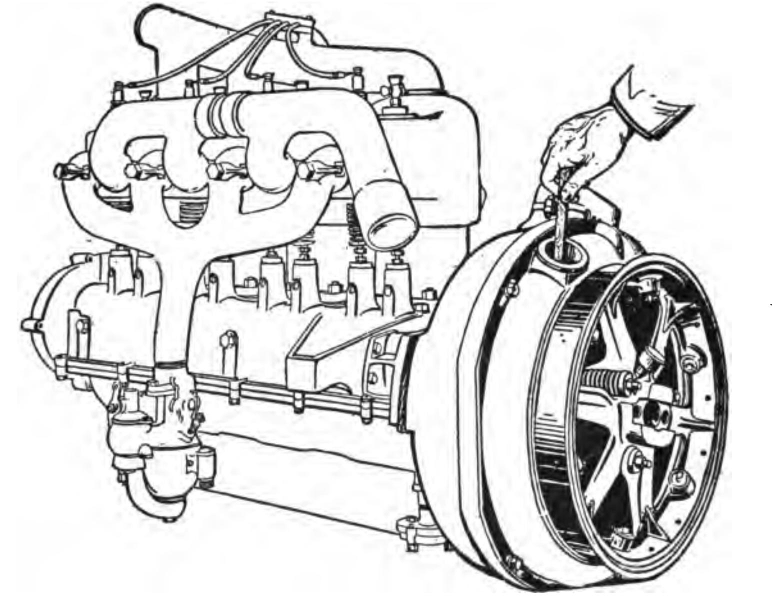


FIG. 21.—U. S. L., starter and lighter armature that revolves in place of the usual engine fly wheel.

Electric Starters Require a Storage Battery.—In any electric system a storage battery is always necessary; for, in order to crank a gasoline engine there must be some source of electrical energy from which the cranking motor may draw its supply of electricity. Without it there would be no electric cranking devices. The first function, therefore, which the storage battery serves is to supply electricity for starting purposes.

* NOTE.—There are two classes of two unit starter as explained on page 31.



PLATE—OVERLAND ENGINE EQUIPPED WITH THE U. S. L. ELECTRIC STARTER, SHOWING HOW TO CLEAN THE COMMUTATOR WITH A STICK OF WOOD.

Starting—To start the gasoline engine, get the spark and throttle levers on the steering wheel just as you would if you were going to crank the engine by hand. Be sure that the transmission gears are set in neutral, so as not to start the car itself. Turn the ignition switch to the position marked "on."

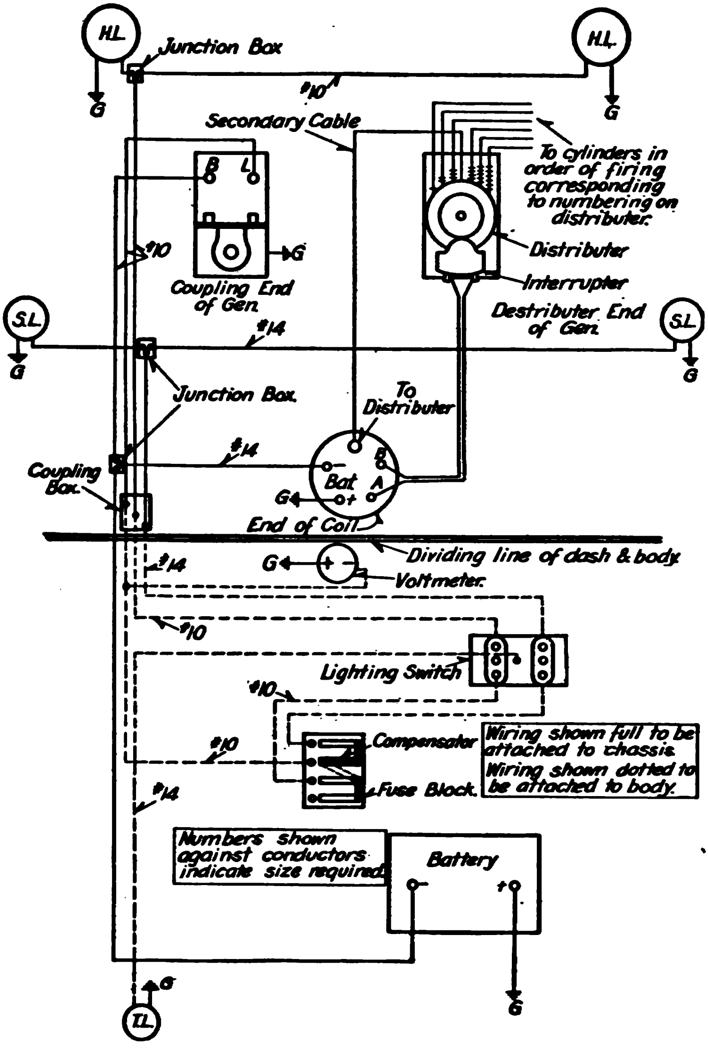
Press the foot button all the way down and hold it until the engine starts by itself. If you hold the starting button down after the engine begins to work, this will tend to discharge the storage battery still further. If, after a few seconds, the cylinders do not fire, investigate.

Do not exhaust the storage battery by turning the engine over and over with the self starter. Examine the wiring. See that all wires are secured to their corresponding terminals and that there are no breaks. There is probably some trouble with the engine. The starter has performed its functions.

After the car is under way, the indicator of the regulator will show when the battery is being recharged. A speed of from eleven to fourteen miles an hour is necessary before actual recharging begins.

Attention and Care—The motor generator requires no special attention. A hole is provided in the lower part of the housing through which any oil coming from the engine will drain.

If oil or dust collect on the commutator, clean it off with a soft pine stick cut so that it may be inserted between the brush-holder rings until it rests upon the commutator. The engine should be turned over very slowly when this is done. The brushes are ground in before they leave the factory and need no further adjustment or attention.



PLATE—DIAGRAM OF WESTINGHOUSE IGNITION AND LIGHTING SYSTEM.

The chief features of the Westinghouse electric ignition and lighting system are: GENERATOR: Low speed; direct driven; enclosed; self-regulating; no permanent magnets. IGNITION: Dual system; no vibrators or multiple-unit spark coils; automatic spark advance; two series contacts in interrupter; safety spark gap protects ignition coil; ignition switch combined with coil.

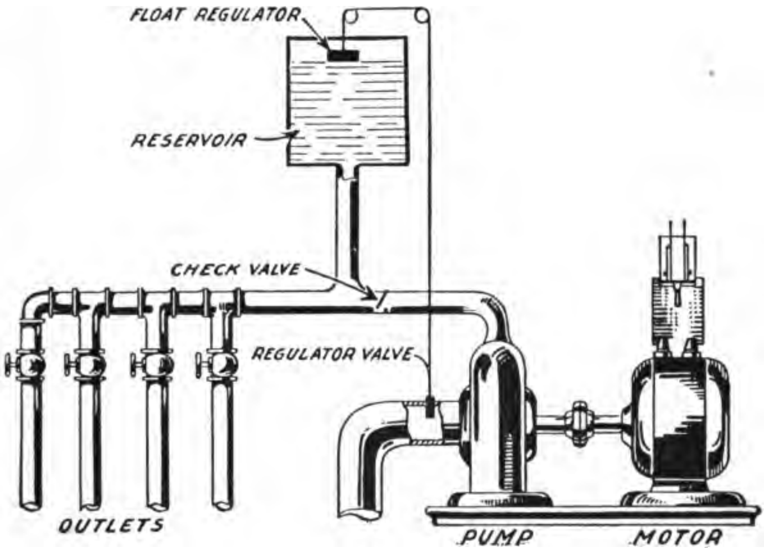


FIG. 22.—Hydraulic analogy of the Delco system. The arrangement and operation of the Delco electric system of starting and lighting may be compared to a pressure system of water supply such as is commonly used in isolated plants for private reisdences, etc. Such a water system usually comprises a power driven pump, connected by a main line to the various outlets, and a tank or reservoir placed at a height which will give the desired head or pressure, and connected to the main line in the manner shown in the illustration. The pressure tank or reservoir is provided with a regulator usually of the float type, adapted to indicate the amount of water in the reservoir and also designed to automatically shut off the power when the water has reached a certain predetermined level. In the main line, between the pump and the tank, is placed a check valve, the purpose of which is to prevent the backward flow of water into the pump in case the pressure of the water in the reservoir exceed that of the pump or in case the pump be stopped. **The operation of the system just described is as follows:** The pump, being directly connected to the electric motor, is adjusted to run at a speed which will supply approximately the amount of water required or slightly in excess of this quantity. The pump is operated until the reservoir is filled to the point at which the float regulator acts and the motor is stopped, then the system is ready for use. If one of the outlets be opened, and water be allowed to flow continuously, the water thus drawn off is taken from the quantity stored in the reservoir, and when the level of the water in this reservoir drops to a certain predetermined point the float regulator will cause the switch to be closed, thus starting the motor which drives the pump. The operation of the pump in this case will be to supply the water to the outlet from which the water is flowing, and any water in excess of the quantity thus drawn off will be pumped into the reservoir. When the water thus pumped into the reservoir has filled it to the point at which the switch will be operated, the pump will be stopped, and if the water continue to flow from the outlet, the above operation will be repeated indefinitely. If enough outlets be opened so that the flow of water is equal to the quantity supplied by the pump, the level in the reservoir will remain constant, while if the quantity drawn off at the outlets be in excess of the quantity supplied by the pump, the deficiency will be taken care of by the water in the reservoir until its supply is exhausted.

When the car comes from the manufacturer, the storage battery will be filled with electricity, and it must be kept charged. If a dynamo be provided on the car, this may serve to charge the battery whenever the car is in use. Unless such a generator be supplied, it will be necessary to periodically recharge the battery.

Batteries designed solely for ignition or lighting are not

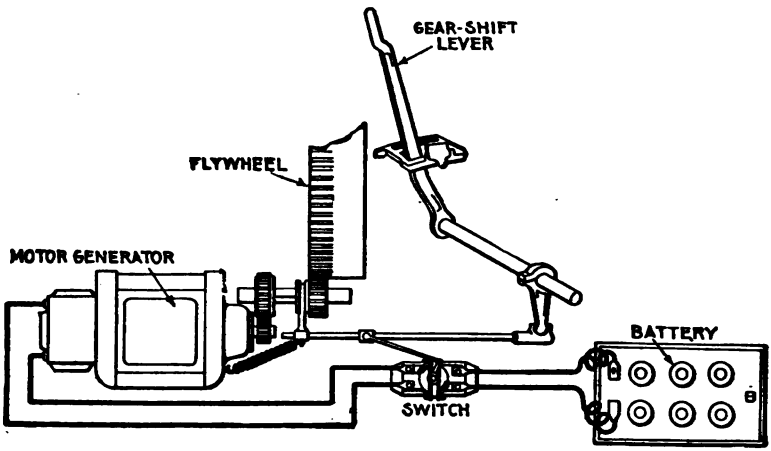
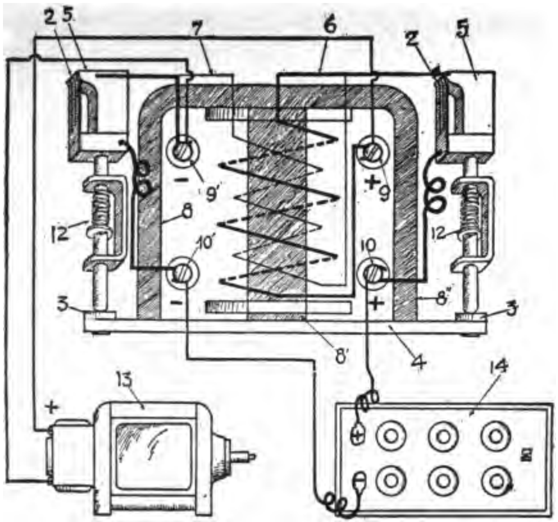
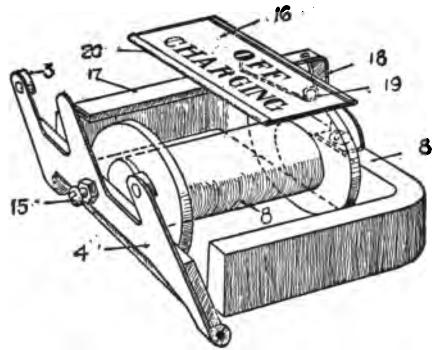


FIG. 23.—Leece-Neville system as installed on the Haynes car. It consists of two separate but correlated elements, the generator and cut out, and the battery, starting motor, and lamp system. The 12 volt generator is situated on the right side of the engine and is driven from the right cam shaft. It is wired to a cut out on the dash, which alike automatically prevents overcharge of the battery and leakage of current from thence to the generator armature at slow speeds. The battery is carried on the left running board, and is of 100 ampere hours capacity. All five lamps are supplied from this battery, but three wires being used in connecting them. The cranking motor, which also is supplied from the battery, has, like the generator, but two connections. It is geared to the flywheel by means of teeth cut in the latter's periphery, a sliding gear on a short idler shaft, geared direct to the motor armature, meshing with these teeth. The starting motor is fastened on the left side of the engine, forward of the flywheel and beneath the frame. The control of the sliding gear presents perhaps the greatest novelty yet introduced. This control is by means of the gearshift lever. A small gate pedal on the quadrant raises a lid over the starting slot, permitting the lever to enter it for the purpose of starting. A quick, vigorous forward thrust on the lever in this position throws the sliding gear into mesh with the teeth on the flywheel and starts the engine. Upon the response of the engine, the lever, on being released, is automatically returned to neutral by means of a spring, and the gate closed; when the lever is used in its normal function of gear shifting. The quadrant is further notable in that it is completely and legibly calibrated to avoid confusion of its many functions. It is provided with a small perforated lug, the hole in which registers with a corresponding hole in an extending arm of the lever to be locked so by a padlock.

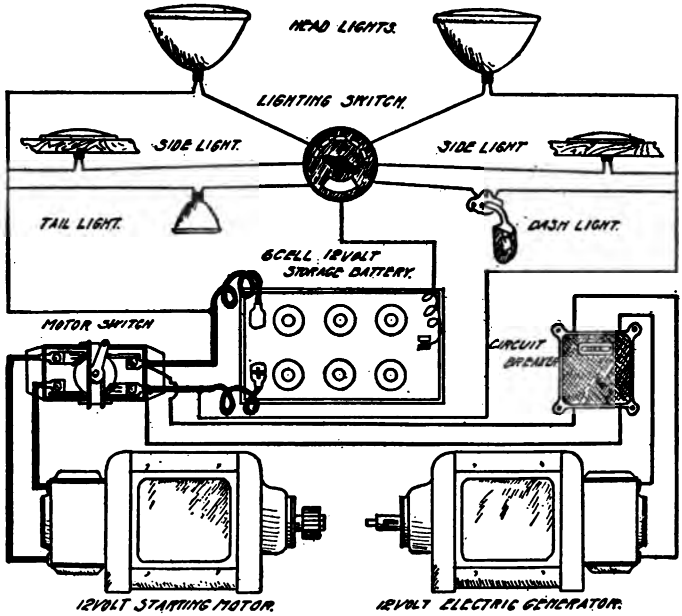




PLATE—THE LEECE-NEVILLE TWO UNIT ELECTRIC STARTING AND LIGHTING SYSTEM.

Breaker contacts 1, 2 and 5 are shown closed as when the generator is charging the battery. Indicating target omitted for the sake of clearness.

The electric generating and storage plant commences operation as soon as the engine starts by generating current in the generator. This first current flows from the generator through the winding 7 on the magnet 8 until the energy is sufficient to attract and close the armature 4. This action closes the charging contacts 1, 2 and 5 when the bulk of the current flows through the heavy wire winding 6 to the battery and the energy is there stored for use in cranking, lighting, etc.



WIRING DIAGRAM
THE LEECE-NEVILLE ELECTRIC LIGHTING AND STARTING SYSTEM.

PLATE—THE LEECE-NEVILLE TWO UNIT ELECTRIC STARTING AND LIGHT SYSTEM—*Continued*.

When the armature closes it also operates the indicating target and shows the word "charging" on the face of circuit breaker to the operator. When the generator stops running the magnet 8 is no longer energized and springs 12 push the armature back and open the charging contacts 1, 2 and 5, thus breaking the electric connection between generator and battery on both the positive and negative sides. At the same time spring 19 operates the indicating target to show "off" on the circuit breaker to the operator. The indicating target shows the word "off" in the little window of its case when generator is not charging, and when the generator is "charging", this word is shown instead of "off". The wiring diagram shows the generator connected through the circuit breaker to the storage battery and the battery connected to the motor through the motor switch and the lamps through the lighting switch. Standard 6 volt lamps are used in connection with the 12 volt battery by connecting them thereto by a three wire system. All the lamps are connected on one side through the lighting switch to a central terminal on the battery and on the other side one-half of the lamps are connected to the positive pole of the battery and the other half of the lamps are connected to the negative pole. Thus we have divided the 12 volt battery into two 6 volt batteries for lighting without in any way interfering with its being charged by the generator at 12 volts or discharged through the motor at 12 volts.

capable of taking care of the sudden and large demand for current to operate a starter.

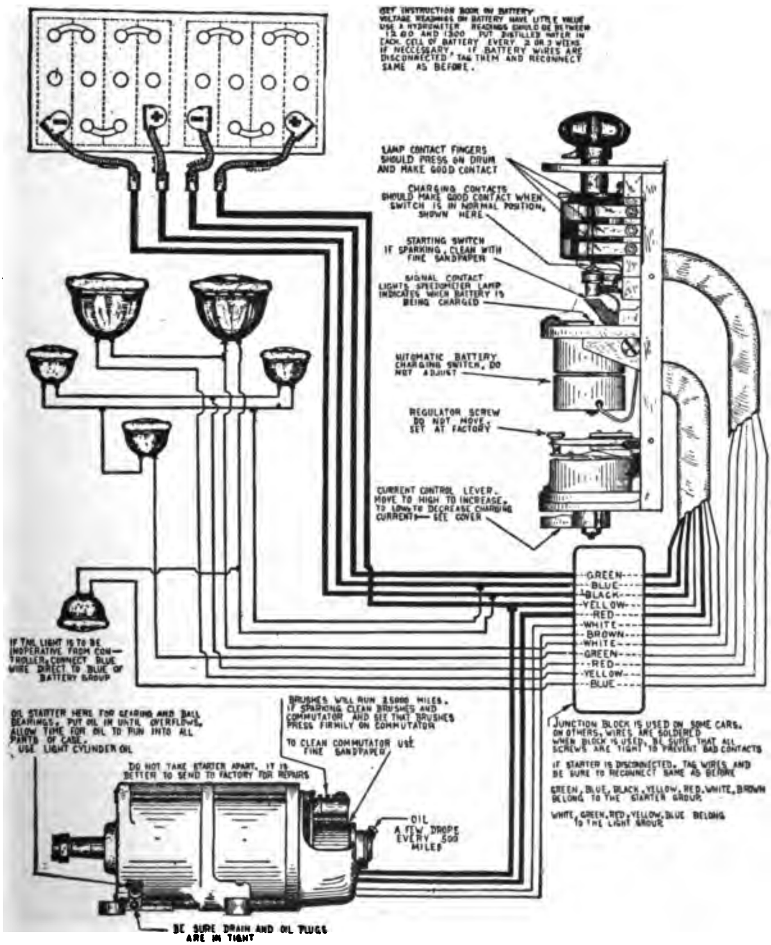


Fig. 24.—Wiring diagram of the Jones, Jesco, starting and lighting system, 8-16 volts with separate controller.

Storage batteries used for lighting, igniting and starting, while they resemble one another externally, are quite different in their internal construction. This particularly applies to batteries which have to be used in conjunction with an electric cranking motor on an automobile.

The lighting battery which has been extensively used during the past two seasons is very similar to the one which is now supplied for electric starting. It lacks capacity more than anything else to make it applicable to the latter duty. On the other hand, the ignition battery is inapplicable to either lighting or starting duty. Just as the lighting battery lacks capacity for starting purposes, so does the one used for ignition purposes, only that the latter is lacking in a greater degree than the former. Making a comparison with six volt batteries, the capacity will depend only on the number of amperes discharged continuously.

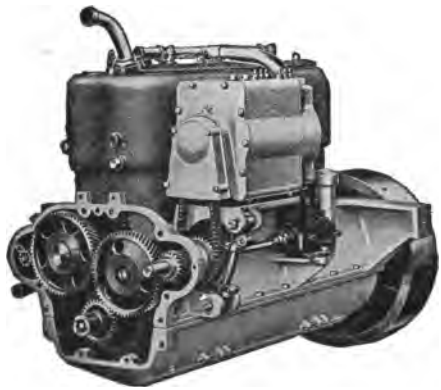


FIG. 25.—**Entz** single unit starting and lighting system; view showing mounting of motor generator on engine and silent chain drive.

A starting battery is rated at 100 ampere hour capacity when it will discharge at the rate of 5 amperes for 20 hours continuously. A lighting battery with a rating of 80 ampere hours capacity will give five amperes for sixteen hours continuously. The ignition battery rated at 40 ampere hour capacity will give only ½ ampere, but will deliver this for 80 hours continuously. For lighting, a battery should always be able to deliver at least five amperes continuously for ten hours. This would easily be accomplished by the lighting and starting battery, but would be impossible with the ignition battery. The latter is not designed to give such a high rate of discharge.

There is little difference in the construction of lighting and starting batteries. The greatest difference in these is the capacity. Capacity in this case only means a greater factor of safety. Therefore, it may be

said, that the construction of the ignition battery prohibits its use for starting purposes, but that a large lighting battery may be used for starting, because it is of the same general construction as that generally used with electric cranking motors.

The principal difference between batteries designed to give a slow discharge and a quick discharge is found in the plates—the ignition type of battery having a few thick plates, while the lighting and cranking battery has many thin plates.

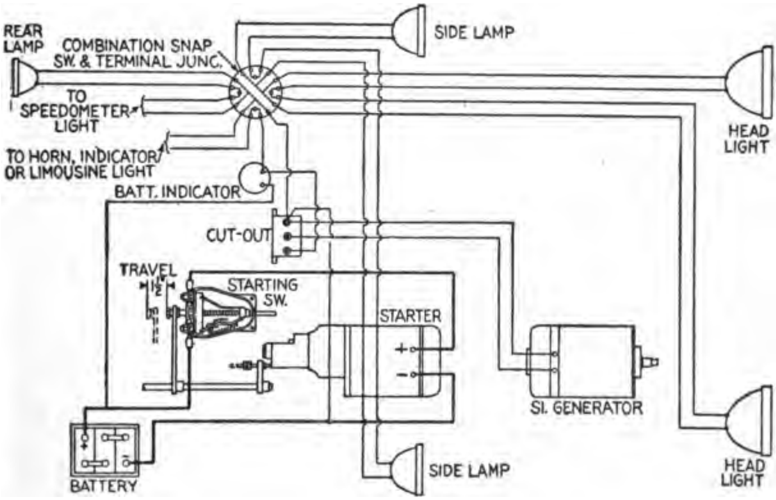


FIG. 26.—Wiring diagram of **Deaco** single unit starting and lighting system. Heavy lines indicate No. 4 B. & S. stranded flexible cable. Medium lines from motor-generator and starting switch to combination snap switch and terminal junction indicate No. 10 B. & S. gauge duplex wire. Fine lines in lamp circuit indicate No. 12 B. & S. gauge duplex wire.

The essential requirement for rapid discharging is large plate area per ampere discharged. This is just what is accomplished by the use of thin plates; for when two plates replace one, the effective area is doubled.

In practice this doubling of area is accompanied by the reduction in thickness of plate, in order to keep the size of the battery about the same as before. It also has an important bearing on the discharge rate which may be obtained from a battery, and also the capacity or length of time that the battery will give this discharge. The gain is due to the shortening of the distance which the electrolyte has to travel to reach the center of the plate.

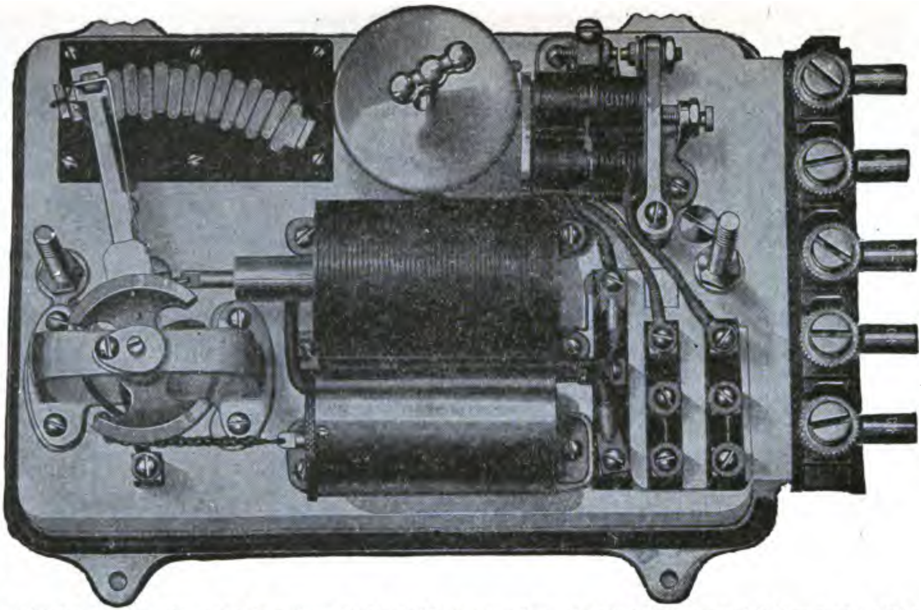


FIG. 28.—Adlake-Newbold regulator. It has a solenoid which automatically varies resistance in series with the dynamo field, and a cut out which automatically disconnects the dynamo from the work circuit when the voltage is below that of the work circuit. In other words, the regulator performs automatically, and in the same way, what is done by manual control in stationary lighting plants. There is no departure from the well established principles of dynamo control. The dynamo is a shunt wound direct current machine and in series with the field are properly graduated resistances which form a part of the regulator. A solenoid in the regulator carrying the current generated by the dynamo works against gravity as a constant balancing force to operate an arm contact, varying these resistances to compensate for variations in the speed of the engine. The regulator thus maintains a constant output from the dynamo, regardless of speed. This regulator is so designed and constructed that when the lamps are not burning, or when side lamps or tail lamps only are being used, the dynamo cannot exceed an output of five amperes, regardless of car speed. When the front lights are turned on, there is an automatic increase to ten amperes, to take care of the additional load of the front lamps. Under unusually severe service conditions in winter, the pulling out of a small switch A in the upper left corner of the regulator maintains a constant output of ten amperes. It is possible by adding shot to the counterbalance B to further increase this output from ten amperes to fifteen, and the dynamo is in every way capable of carrying this excess load continuously. The regulator, mounted on the dash, further gives an indication of operation, and a pilot light in socket C which burns only when the dynamo is generating, illuminates the moving arm.

Choice of Voltage.—In designing starters there are several conditions to be considered in determining what voltage shall be used, especially as the starter problem is somewhat different from the ignition and lighting requirements as to voltage, and one battery is generally employed for all.

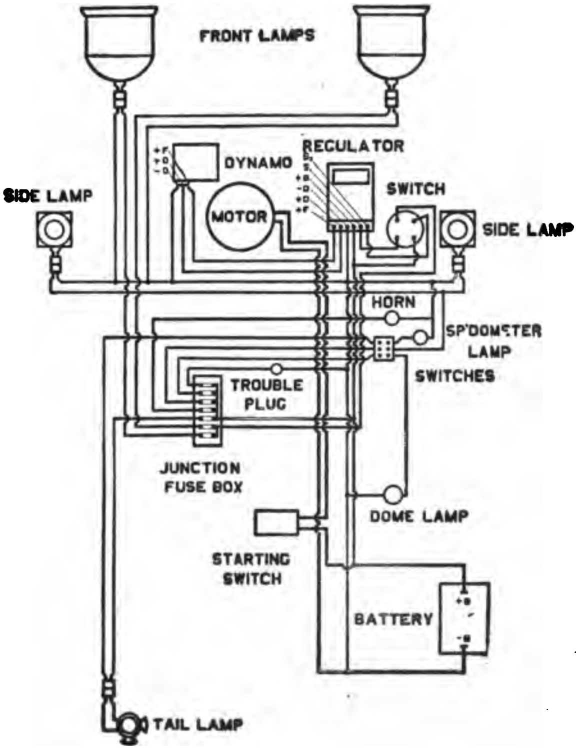
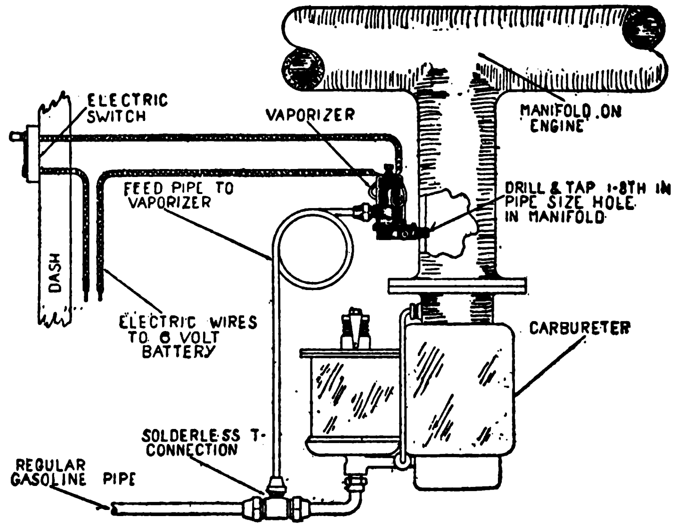


FIG. 28.—Wiring diagram of Adlake lighting and starting system.

The pressure used on the different lighting and ignition systems is six volts, and were it not for the problem of cranking, there probably would not be any reason to change. This low



PLATE—ELECTRIC VAPORIZER AND CONNECTIONS.

This is a device which is supplied with gasoline from the main feed line and which heats the fuel by using electric current from any 6 volt battery sufficiently to generate vapor in cold weather. To determine proper location of vaporizer, it is necessary to take into consideration the following: On all cars using gravity gasoline feed, the vaporizer should be placed as low as possible on intake manifold. To insure positive flow of gasoline to vaporizer it may be necessary to place vaporizer in neck of carburetter also where the manifold is made of thin brass tubing, but in no case must vaporizer be placed below throttle valve. Thin brass tubing can easily be reinforced. On cars using pressure gasoline feed, vaporizer may be located any place on main part of intake manifold that will insure equal distribution of vapor to all cylinders.

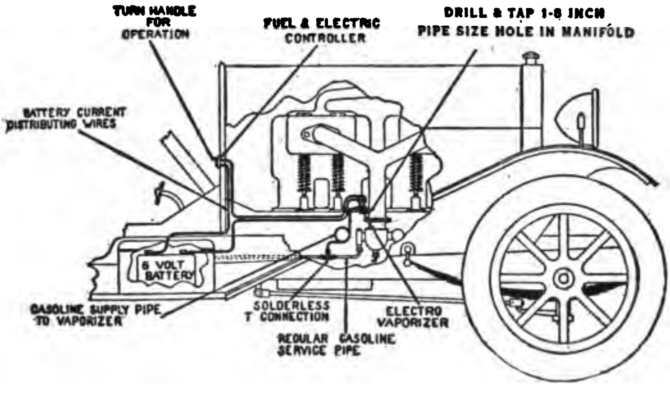


PLATE *ll*—ELECTRIC VAPORIZER AND CONNECTIONS—*Continued.*

Caution—When determining location of hole into which vaporizer is to be screwed, be absolutely sure that there is nothing in the way against which vaporizer will strike while making the circle as it is screwed into position; do not insert any pipe between vaporizer and manifold.

After determining location of vaporizer as per above, drill and tap ⅛ inch pipe size hole, then screw vaporizer into this hole. Be sure to have vaporizer in an upright vertical position.

Cut section out of gasoline feed pipe in a convenient place near carburetter. The length of this section should be determined by the length of the T connection after end nuts have been removed. Note flare or bell shaped end of small pipe attached to the solderless T connection and flare ends of the main gasoline pipe in like manner. An ordinary center punch may be used for this purpose. Use a center punch somewhat smaller than inside diameter of gasoline pipe, rotate in a circular manner so as to spread end of pipe, but do not use enough force to split pipe. Be sure to place nuts taken from T connection on tubing before flaring the same. Insert T connection and connect end of small pipe to vaporizer, as shown in sketch. Be very careful that no dirt or foreign matter gets into vaporizer or pipes and make certain that all nuts are tight to prevent any leakage of gasoline.

To Connect Electrically—Attach two wires to the terminals at top of vaporizer, connect these wires to switch on dash and battery as shown in sketch. Switch may be placed at any convenient spot. This makes a direct connection from battery to vaporizer. Any 6 volt storage battery will furnish current to operate vaporizer. Use No. 18 lamp cord for wiring.

Operation—Prepare car in usual manner for starting except to not open gas throttle more than a quarter the usual distance. Turn on vaporizer switch. Wait about 10 seconds and proceed to start engine in usual manner. As soon as engine is running, change throttle to usual position and shut off vaporizer switch. Under extremely cold weather conditions leave vaporizer on a little longer than at other times.

If engine be hot, carburetter should supply sufficient gasoline vapor for starting and it should not be necessary to use vaporizer, as vapor from both carburetter and vaporizer will make an over rich mixture. Adjusting screw will be found directly underneath intake connection on vaporizer.

To Adjust—Open valve by turning adjusting screw to left about $\frac{1}{16}$ to ⅛ of one turn, or a little more if required. In some few cases it may be necessary to reduce flow of gasoline by turning adjusting screw to right a very little. By turning adjusting screw to right as far as it will go shuts off vaporizer entirely. A very fine screen in intake end of vaporizer may need to be cleaned occasionally.

pressure has the advantage that it is easy to protect the circuit from electrical leakage, just as the gaskets and stuffing boxes of a low pressure steam engine are easily kept tight.

Six volt lamps are manufactured with less difficulty than those designed for higher pressure, and they are to be obtained anywhere. The weight of six volt batteries is less than that of the higher voltage type. Were it not for these considerations,

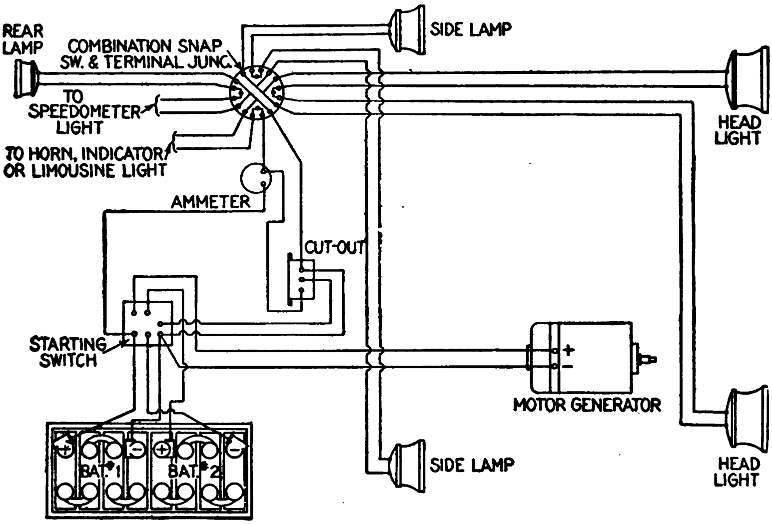


FIG. 29.—Wiring diagram of Deaco two unit starting and lighting system. Heavy lines indicate No. 0 stranded flexible cable (259 or No. 24 B. & S. gauge wires, 3/64 rubber walls, and single braid cotton. Medium lines from generator and battery to combination snap switch and terminal junction indicate No. 10 B. & S. gauge duplex wire. Fine lines in lamp circuit indicate No. 12 B. & S. gauge duplex wire.

starting motors would be designed for high pressure, as they are smaller and consequently lighter. High voltage for the motor does not necessarily mean high voltage for the generator and lights.

There are three general combinations:

1. All one voltage, either 6, 12, 16, or 18 volts;

2. Generating and starting at 12, 16, or 18 volts, and lighting at 6, 8, and 16 volts respectively.
3. Generating and lighting at 6 volts, and starting at 24 or 30 volts.

One Unit Systems.—The term "one unit" as applied to an electric starting system means that there is a motor and dynamo combined in one machine, or motor-dynamo, as it is called,

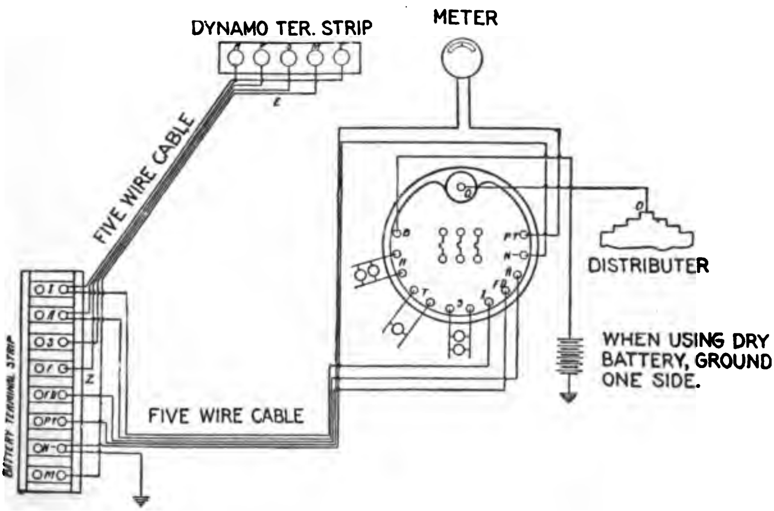


FIG. 30.—Wiring diagram showing outside connections of Electro single unit, starting, lighting, and ignition system. The meter should show "charge" when engine is running, and "off" when not running "discharge" will show when lamps are burning and engine not running.

the dynamo furnishing current for the starter, and for charging the storage battery.

In classifying a system as having one or more units, it means that the apparatus provided for generating the current and the motor for starting the engine consists of one or more parts.

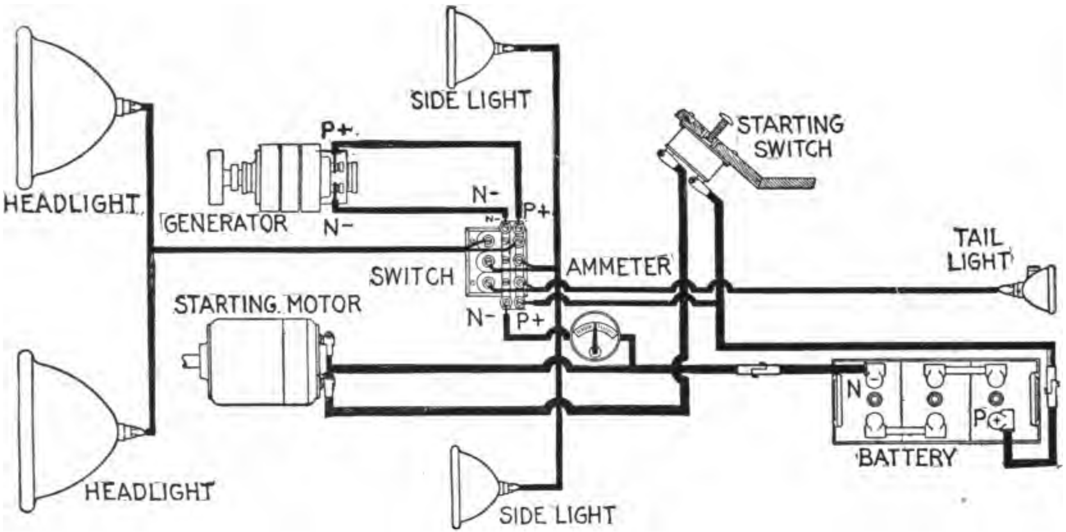


Fig. 31.—Wiring diagram of Auto-Lite two unit starting and lighting system. The dynamo being driven by the engine, from a sprocket on the crank shaft, (or some shaft operating at the same speed), by a silent chain and it is mounted on a substantial base or bracket on the engine. During such time as the electric lamps are burning, and the engine is running, the current for operating them is supplied direct by the dynamo, any surplus not being consumed being stored by the battery. When the engine is running in the daytime and no current is being consumed by the lamps, the entire amount of current being produced is being stored in the battery. The dynamo has a speed governor contained in a drum that is a part of the drive. A reverse current circuit breaker is placed between the dynamo and battery to break the circuit when the battery pressure exceeds that of the dynamo. The circuit breaker is housed between the magnets of the dynamo and is a part thereof. An ammeter reading in both directions for zero is mounted on the dash. The capacity of battery is 120 ampere hours.

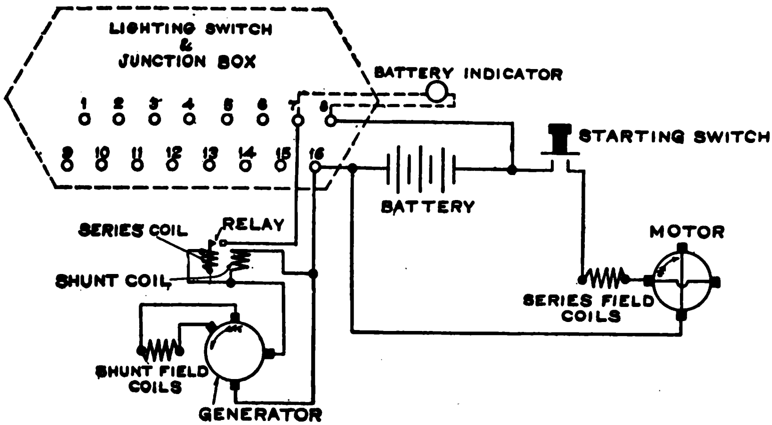


FIG. 32.—Wiring diagram of **Wagner** two unit starting and lighting system. The connections shown in dotted lines are put on by the automobile manufacturer, and they may or may not be correct for all cars using the **Wagner** system of starting and lighting. However they are correct for a Studebaker car.

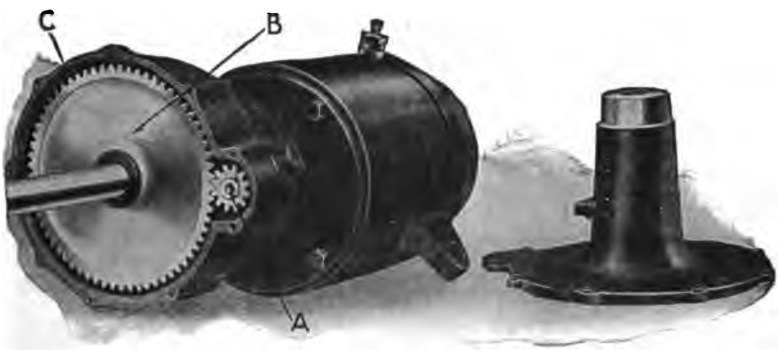


FIG. 33 and 34.—**Wagner** starting motor of two unit starting and lighting system. It is series wound, and equipped with reducing gear, with a gear reduction for reducing the speed of the motor so that it will be suitable for cranking the engine. This gear equipment consists of a small steel pinion A on the motor which meshes with a large steel gear B on the back shaft, thereby reducing the speed. These gears are encased in the cast iron housing C. The motor is connected to the engine by means of a chain which operates from a sprocket on the starter to a sprocket on the engine shaft. The motor is adapted for electrical connection to the battery by means of a starting switch. This switch is usually installed on the foot board of the car, and when the pedal is pressed down, contact is made between the battery and the starter, thereby cranking the engine.

Thus, as just stated, in the one unit system there is a combination dynamo and motor forming one machine, or "one unit."

An example of the one unit arrangement is the Electro system, which has a combined motor and dynamo, the latter furnishing current for starting ignition and lighting.

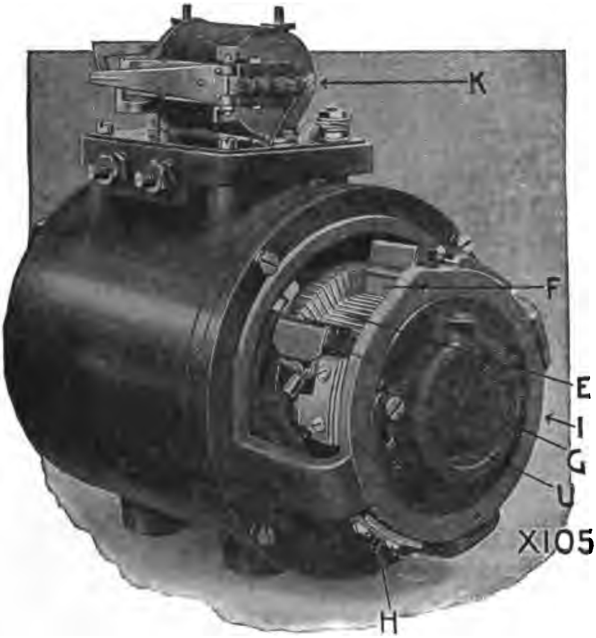


FIG. 35.—**Wagner** dynamo of two unit starting and lighting system. The drive is through a tram of gears or equivalent. The windings and internal connections are of such character that no regulating devices are required except a relay. In construction, the commutator E and brushes F, G, H, and I, are located under the cover which in this cut is removed. The brushes H and I collect the current from the commutator and furnish this current for charging the battery through the relay K. The brushes F and G, collect the current from the commutator and furnish this current for exciting the fields. The relay K is shown in detail in fig. 36.

It is necessary to arrange the motor with a short driving shaft integral with the motor case, driven either through the timing gears or silent chain and connecting to the starter with an Oldham coupling. The motor dynamo is always in operation. When turning below 380 revolutions per minute it is a motor, and when turning above that rate, a dynamo.

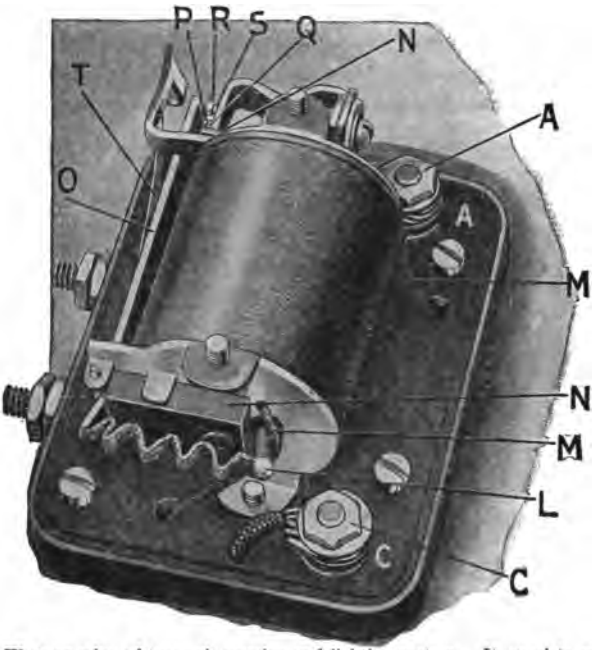


FIG. 36.—Wagner relay of two unit starting and lighting system. It consists of two magnet coils L and M, wound on an arm core N, which attracts and repels an iron lever O. At the end of O are two main contact points P and Q at which the contact between the dynamo and battery is made and broken. There are also supplied two auxiliary contact points R and S which are for the purpose of minimizing sparking at the main contact points P and Q The coil M called the *shunt coil* is connected directly across the two brushes H and I, and therefore the full dynamo voltage is impressed across the ends of this coil. The coil L, called the **series coil,** is connected in series with the battery and dynamo and therefore this coil carries the charging current when the battery is being charged **In operation:** when the engine is started, the dynamo is driven by the engine and it, therefore, increases and decreases in speed with the engine. When the engine is speeded up, the dynamo follows with corresponding increase in speed and the voltage of the dynamo rises as the speed increases. As soon as the dynamo voltage gets to a point above the voltage of the battery, which is approximately six volts, the coil M **pulls** the iron lever O **toward** the magnet core, thereby **closing** the contact at the points P and Q-R and S. As soon as this **contact is made,** the dynamo is connected to the battery, and a **charging current** willl flow from the dynamo to the battery through the series coil L, which is in series with the dynamo and battery. The dynamo continues to charge as long as these contact points P and Q-R and S remain together, but when the engine speed is decreased, so that the dynamo voltage falls below the battery voltage, the battery will discharge through the dynamo and therefore through the coil L. This discharge current, being in the **opposite direction** from the charging current, will neutralize the effect of coil M and allow the spring T to pull lever O **away** from the magnet core, thereby opening the contact at the points P and Q-R and S. As soon as these contacts **open,** the battery is **off charge. The engine speed at which this relay closes corresponds to a car speed of 7 to 10 miles per hour.**

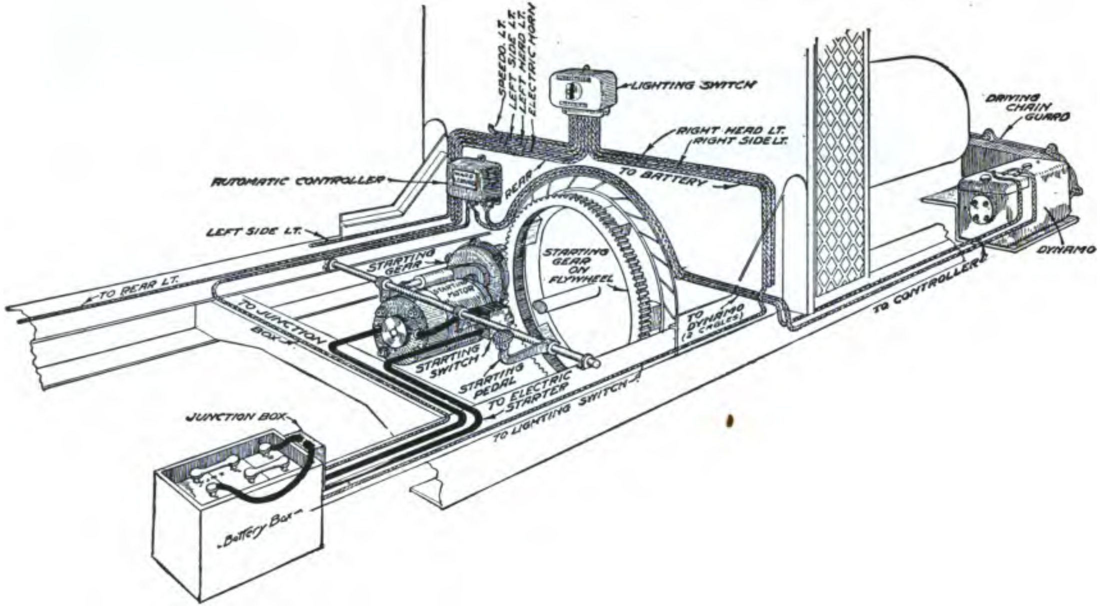
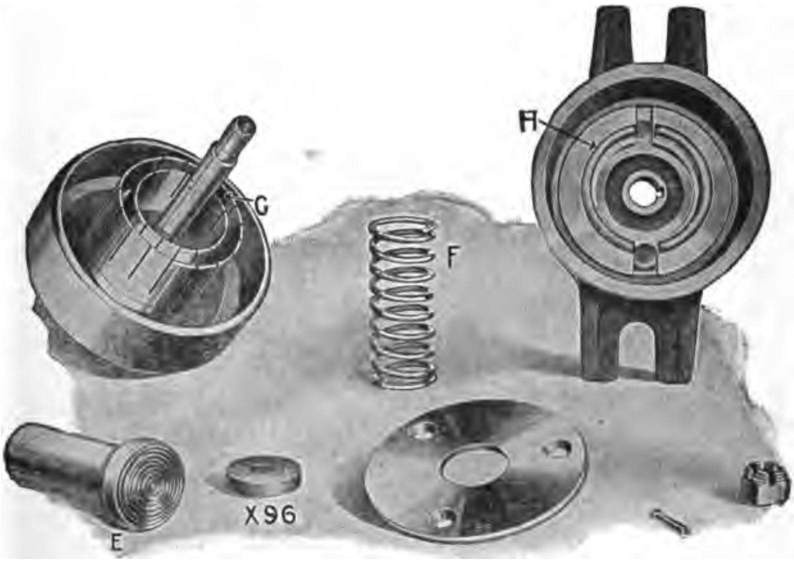


Fig. 37.—Diagram of connections of Ward Leonard lighting and starting system. This is a two unit system. The dynamo is a 6 volt shunt wound machine. The starting motor is series wound of the totally enclosed type. The type of gearing used is dependent upon the most convenient and best method of locking the motor on the engine. The relay or so called automatic controller is so arranged that the dynamo will not charge above a 10 ampere rate no matter how high the speed of the car, but at all speeds greater than a predetermined speed (about 15 miles per hour) the dynamos will produce a substantially constant current.

The compound differential winding takes care of the output from the generator. No discriminating cut out or reverse current circuit breaker is provided to disconnect the battery from the motor dynamo entirely at very low speeds. Instead of this, the ignition switch breaks the line between the battery and generator when the engine is stopped by cutting off the ignition.

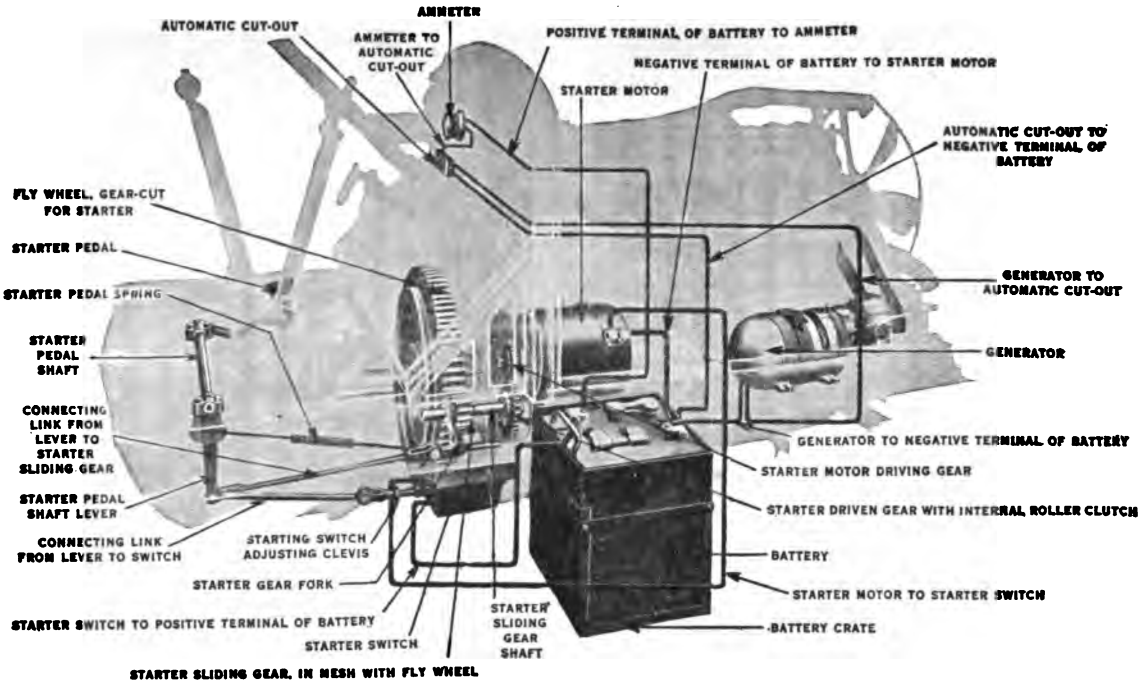
The system operates on 24 volts, but charges the battery at six volts. The amperage drawn by the 24-volt motor when turning over the gasoline engine varies with the size of the motor as in all systems.



FIGS. 38 to 45.—Exploded view of **Wagner** starting switch. When the heel pedal E is pressed down with the foot, it compresses the spring F and at the same time brings the contacts G and H together. This closes the circuit and the motor will crank the engine. When the heel pedal is released, the spring forces it to its original position, thereby forcing the contacts apart. This will open the circuit and the motor will stop.

The gear reduction between the motor dynamo and the engine is twenty-five to one when starting but changes automatically to a direct drive when the engine starts running.

Two Unit Systems.—There are two classes of two unit systems: one in which the motor and dynamo are combined in



PLATE—GRAY AND DAVIS ELECTRIC SELF STARTER AS INSTALLED ON THE LOZIER CAR.

This is a two unit system, and comprises a dynamo, storage battery, discriminating cut out, starter, motor and resistance switch.

PLATE—GRAY AND DAVIS ELECTRIC SELF STARTER AS INSTALLED ON THE LOZIER CAR—*Text continued.*

The Dynamo Clutch.—This clutch will slip more or less according to speed of engine. It consists of a shell secured to a shaft, positively driven from the engine. Held against the inner surface of this shell by two steel springs, are two shoes, faced with asbestos fabric.

The constant pressure is controlled by two weights and the radial pull of these weights is exactly equal to the spring pressure, minus the frictional driving force of the two shoes.

So long as dynamo is driven at or above rated speed, the equation remains true, and the weights set themselves at a point where the pressure will be sufficient to drive the armature at rated speed (1000 revolutions per minute).

The heat caused by friction of the clutch, is taken care of by the ribbed surface of the driving drum, acting as a fan and drawing air through vents in the outer shell of dynamo.

Generator Clutch Adjustment—All dynamos are thoroughly tested and governors adjusted to hold the proper speed before they are installed on cars, and unless the machine has been tampered with the clutch will require no adjustment.

To Adjust; 1, Remove cover; 2, revolve governor inside of governor shell until the opening in one shoe (marked with a notch) coincides with the drill hole in shell; 3, to increase driving force of clutch, that is, increase output of dynamo, tighten up on screw by turning screw to right. A screw driver 3-16 of an inch wide is best suited for this purpose.

Proper Adjustment: When clutch is in proper adjustment, the ammeter should indicate as follows: 1, All lights off—car running 12 miles per hour or more—4 to 6 amperes, charge; 2, all lights on—car running 12 miles per hour or more—1 to 1.5 amperes, charge; 3, all lights off—engine stopped—0 amperes (neutral position); 4 all lights on—engine stopped—5 lights burning with 16 C.P. bulbs in headlight—7 to 8 amperes, discharge.

Points to Remember When Adjusting Clutch.—1, if the system do not act properly, the trouble is probably *not* in the clutch adjustment.

The dynamo governor should not be touched except after all other tests and remedies have been exhausted; 2, should the ammeter show little or no increase of current when the clutch is set up, it is a sign that the engine is not up to sufficient speed for charging. 3, that adjusting the clutch does not make the dynamo generate current at lower motor speed; 4, under ordinary conditions the clutch does not wear, and therefore retains adjustment; 5, should adjustment of clutch fail to bring results referred to above, communicate with Gray & Davis Co., giving full details; 6, the governor action is very sensitive and full turn of the screw driver in adjusting, makes a big difference in the dynamo output. Only slight turns should be made each time, continuing until proper adjustment is made.

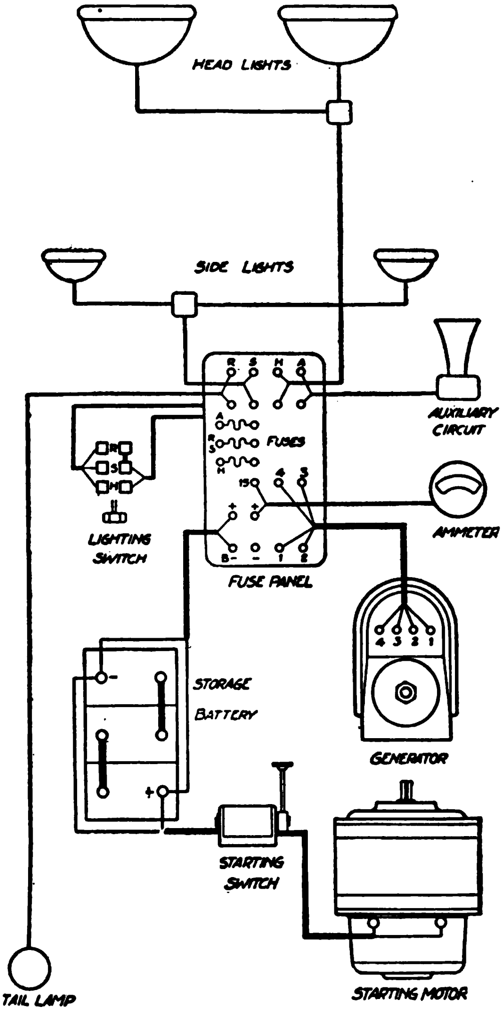
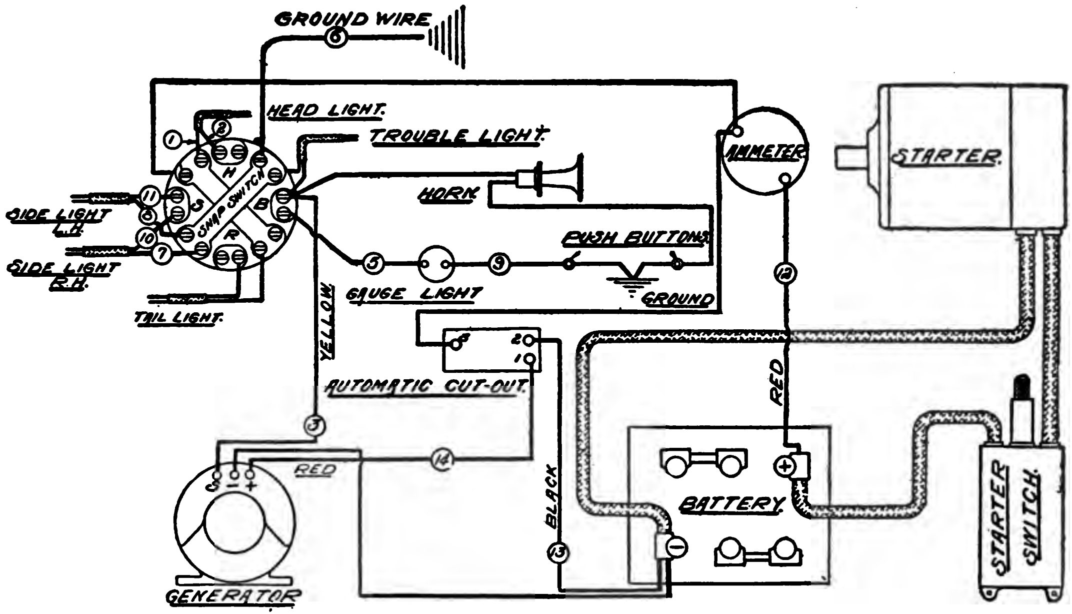


Fig. 46.—Wiring diagram showing complete Esterline two unit lighting and starting system.



PLATE—WIRING DIAGRAM OF ELECTRIC SYSTEM FOR SELF-STARTER LIGHTS AND HORN, AS INSTALLED ON THE LOZIER CAR.

The dynamo of this system (Gray and Davis) is compound wound, but is so wired that the series field winding is carrying current only when the lights are turned on.

PLATE—WIRING DIAGRAM OF ELECTRIC SYSTEM FOR SELF-STARTER, LIGHTS, AND HORN AS INSTALLED ON THE LOZIER CAR—*Text continued*

The connections are as follows: Inside the dynamo the two brush leads are connected directly to the *red* and *black* terminals marked + (positive) and − (negative) on the diagram. From the − (negative) terminal a connection is made to the series field winding, passing around each pole and out at terminal marked S (*yellow* wire).

From the dynamo runs a triple conductor of colored strands, red, black and yellow: *red*, is + (positive), *black* is − (negative) and the *yellow* series S.

The red strand, No. 14, is connected to terminal No. 1 of automatic cut out, and the black strand, No. 13, to terminal No. 2. The current is thus enabled to pass through the fine wire winding of the cut out coil and energize the magnet, which attracts the armature, closing the contact points.

Terminal No. 3 of the cut out is connected to the left terminal of ammeter. The battery connections at this point are very simple. A cable is run from the battery to the dash board, No. 12. The positive, or *red* strand, is connected to the right ammeter terminal and the *black*, or (negative) strand, No. 13, to terminal No. 2 of the automatic cut out. This completes the circuit between the dynamo and the battery, and thus it is seen that the charging circuit is entirely independent of the series field winding.

The lamps are connected into the system by means of the combination switch and junction box, which is connected as follows: Yellow conductor, No. 3, from dynamo lead to crossbar of junction box. The wires from the lamps are brought to the junction box as shown in the diagram.

When the lights are turned on, the current passes from the positive brush of the dynamo to terminal No. 1 of cut out, through cut out to terminal No. 3, to ammeter, but not *through* ammeter, then to junction box, where it divides among the lamps, and then back through the yellow strand, No. 3, to terminal S of dynamo, through the field series to negative (−) terminal, and finally to the negative brush of the dynamo.

Miscellaneous Suggestions on Electric System—If the lights grow dim when the car is speeded up, wires marked S and O in wiring diagram are reversed at dynamo.

If one lamp burn dim, change bulb, if same lamp be still dim, test wire from junction box to lamp, look over lamp connector.

If one lamp flicker, look for poor connection between lamp and junction box.

If all lamps flicker, look for loose connection in switch or at dynamo. See that all circuits between dynamo and battery are intact, and all binding posts and contacts dry.

Be sure that dynamo is up to speed (1000 R. P. M.). See that contact points of cut out actually make contact.

If contact points of cut out do not come together, and ammeter do not indicate current while dynamo is running at speed, push up armature, at bottom of cut out, so that contact is made, then if no current be generated, it shows that there is an open circuit between battery and dynamo.

If ammeter indicate current in opposite direction, that is, on the discharge side, this shows either a loose or broken shunt field wire connection.

To determine whether the open circuit is in dynamo, disconnect dynamo from engine, close contact points at cut out by pushing up armature. Dynamo will run as a motor, and take about 2 or 3 amperes. This will show dynamo connections are all right.

If the ammeter show a discharge when lights are turned off, disconnect battery and if hand go back to zero it shows there is a leak or short circuit, which should be remedied at once. If hand do *not* go back to zero when battery wire is disconnected the needle is bent.

If ammeter indicate a great amount of current and dynamo does not run as a motor, look for broken shunt field connections.

Examine brushes to make sure they are not sticking in the holders. They should work freely. Under no circumstances must a carbon brush be used on starting motor and dynamo.

Special Bronscol brushes must be used; these can be obtained through Gray & Davis Co.

In case of trouble in the electric starting apparatus, look for mechanical defects rather than those of an electrical nature.

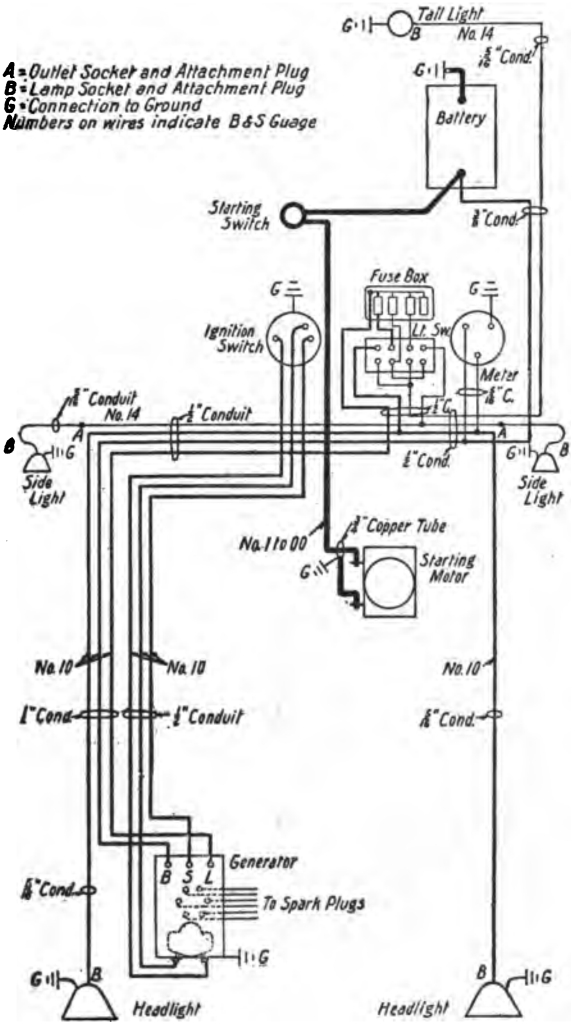
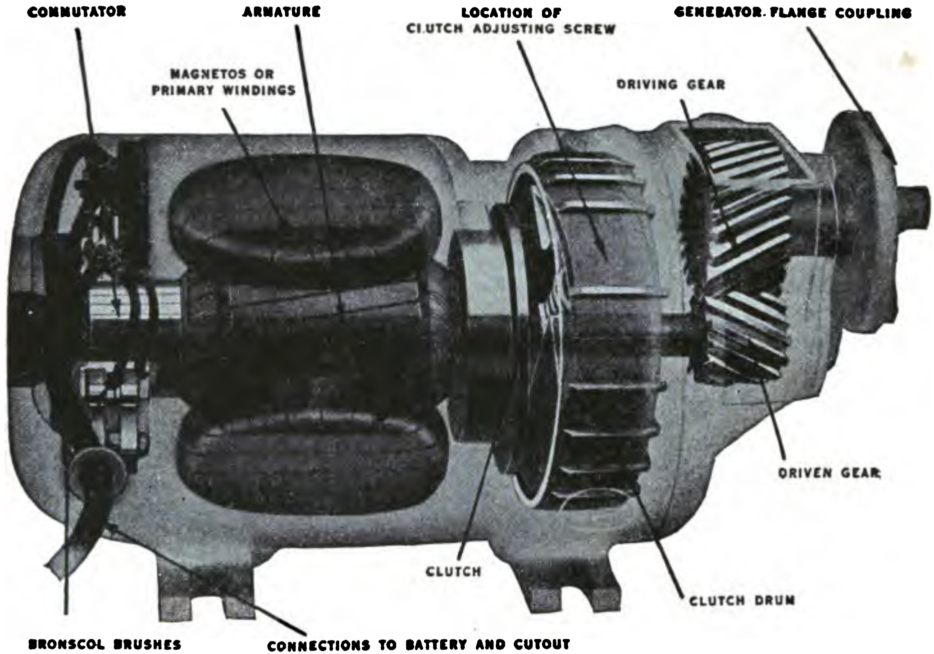
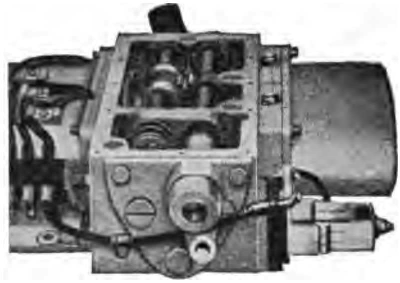


Fig. 47.—Typical wiring diagram of **Westinghouse** starting, lighting and ignition systems.



PLATE—PHANTOM VIEW OF DYNAMO OF THE GRAY AND DAVIS TWO UNIT STARTING AND LIGHTING SYSTEM.



PLATE—THE VULCAN ELECTRIC GEAR SHIFT; HOW IT WORKS.

Assume that the gears are all in neutral and the engine running idle. To move into first speed the operator presses the button No. 1 in the selector switch group, thus connecting up the line from the battery to the magnet No. 1.

The circuit, however, is not yet complete as it is broken by the master switch, which is not closed until the clutch pedal is fully depressed.

The operator, having first selected his gear, depresses the clutch, and the final movement of the clutch pedal closes the master switch, completing the circuit through the magnet or solenoid selected, energizing it and drawing the plunger shaft, to which the shifter fork is attached, into the hollow core of the solenoid.

As the sliding gear reaches the desired position in mesh, its final movement disengages the master switch by means of an automatic tripping mechanism.

The clutch pedal is then released, the clutch returns to its normal position and the transmission is in first speed.

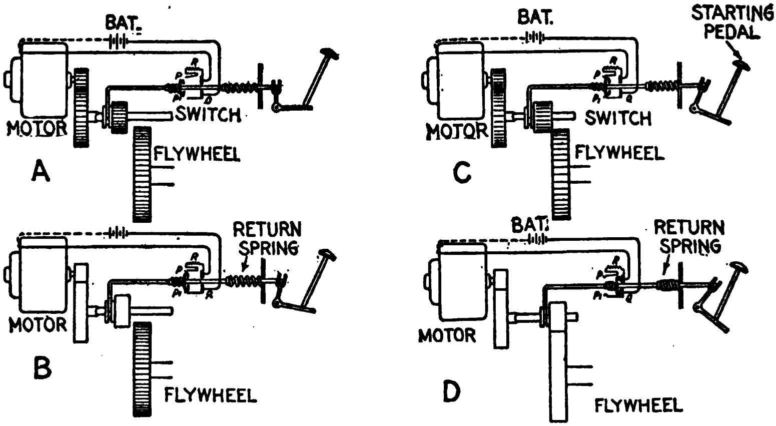
To pass from first to second speed or from third to fourth speed, the operation is repeated.

The view of steering wheels show gear controls as located on post just below wheel.

As shown they are within easy reach of the finger while the hand is on the wheel.

one unit, and one in which the motor and dynamo are separate, the latter being arranged to operate the ignition system when not running on the battery.

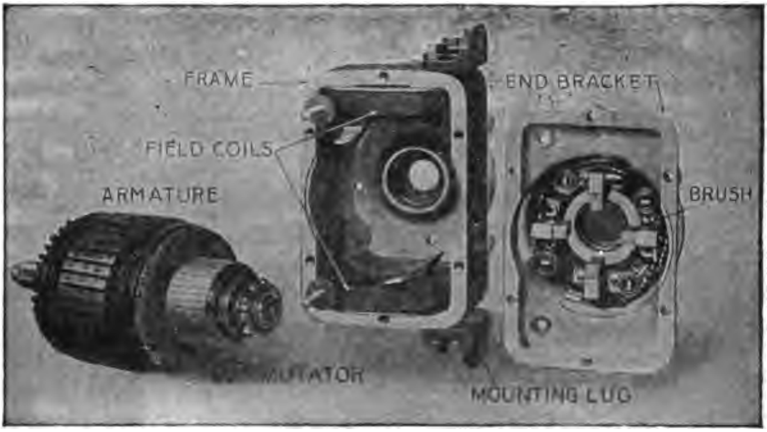
The "Aplco" is an example of the first mentioned class of two unit system. The cranking motor and the dynamo are contained in one



FIGS. 48 to 51.—Diagram of electrical and mechanical connections of motor and switch for flywheel drive of **Westinghouse** starter. In the diagrams, the contact making part of the switch is shown mounted directly on the gearshift rod, though it can be mounted on any rod inter-connected with the gearshift rod. At A is shown the "off" position of the short pinion and switch contactor. Pressure on the starting lever moves the shift rod first to the position B, closing the motor circuit at P and P′ through the resistance R; this starts the motor at a low speed. Further motion of the shift rod to position C opens the electric circuit; the motor and pinion continue to turn, owing to their momentum. When position C is reached, the pinion is still turning slowly so that it cannot fail to mesh with the gear, but as power is turned off of the motor there is no difficulty in sliding the teeth into full engagement. As soon as the teeth do engage, the pressure on the starting lever shifts the rod to position D, closing the electric circuit at Q after the pinion and gear have meshed a sufficient distance to present a good bearing length on the teeth; this connects the motor directly on the storage battery so that full power is developed, and it turns the engine over until the starting lever is released. When the pressure is removed from the starting lever, a spring returns the shifting rod and all parts to position A; this releases the gears and opens the electric circuit, and the motor comes to rest.

unit and the magneto forms the second unit. The make of the magneto is optional and is separate and distinct from the lighting and cranking systems.

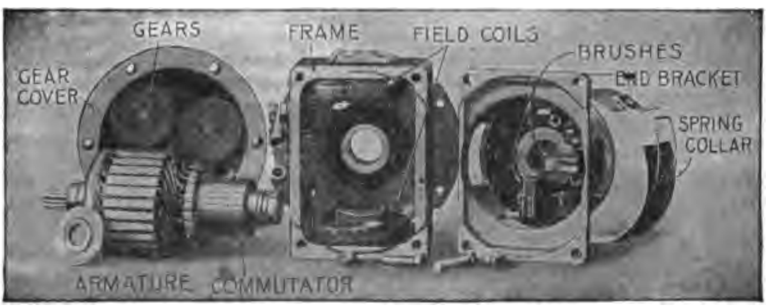
A widely different voltage is used in the cranking motor and the dynamo. The former operates at 24 volts (except in one instance, where 30 volts are used), while the latter operates at 6½ volts.



Figs. 52 to 54.—Parts of Westinghouse starting motor for flywheel drive. The operation of this system is illustrated in figs. 48 to 51.

The dynamo is of the low speed type, being driven at crank shaft speed by chain gears or any other suitable means. It furnishes current for the battery above a car speed of eight miles an hour and charges the battery until it becomes fully charged, when it is automatically switched off, and does not charge the battery again until the latter drops below a point which can be fixed to suit the ideas of the manufacturer.

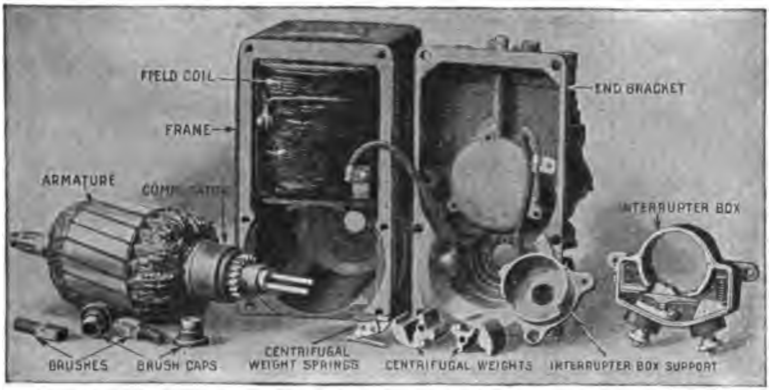
A discriminating circuit breaker or reverse current cut out operates when the voltage of the dynamo drops below that of the battery.



Figs. 55 to 63.—Parts of Westinghouse starting motor for crank shaft drive.

The 24 volt series motor acts through a reduction gear of 40 to 1, between motor and engine.

The Westinghouse system is an example of the second class of two unit systems in which the cranking motor and dynamo are separate machines. The latter not only charges the storage battery but also furnishes direct a supply of current for ignition.



FIGS. 64 to 75.—Parts of **Westinghouse** ignition and lighting dynamo. It may be operated by chain or gear drive from the engine and which supplies electric current to the storage battery and the lights. While the engine is not running, or at very low speed, the lights are supplied entirely by the battery. A magnetic switch in the dynamo automatically connects the dynamo to the lighting system and battery when the engine is running at approximately 8 miles per hour car speed on direct drive. When running on the gears, the switch closes at a much lower car speed. If no lights be then in use, the battery begins to be charged when this switch makes the electrical connection. If the lights be burning, the dynamo furnishes part of the current to them; as the speed increases the proportion of current supplied by the dynamo increases, until at the higher speeds the generator supplies all of the current to the lights, and in addition charges the battery. The amount of current the dynamo furnishes to the battery depends upon the number of lamp burning and the speed of the engine. The ignition outfit consists, in addition to the lighting system and storage battery, of a distributer and an interrupter, which are made a part of the dynamo and an ignition coil and switch. The ignition coil transforms the 6 volts of the battery up to the high tension required for the spark plugs. The interrupter closes and then opens the ignition circuit at each half revolution of the generator shaft, and the distributer directs the high tension current to each of the spark plugs in succession.

The dynamo is of the slow speed type and turns at crank shaft speed on four cylinder engines and 1½ crank shaft speed on six cylinder engines.

The battery circuit is cut in above 10 miles an hour and is cut out below 7 miles per hour. This difference prevents the switch cutting in and cutting out continuously when the speed of the car is at one particular point.

A feature of the Westinghouse system is that the output of the generator varies with the load. When the lamps are switched on, the output of the dynamo becomes great enough to take care of the added load. This is accomplished by having the battery current go through a series field on its way to the lamps, thus assisting instead of bucking or neutralizing the shunt field.

The reduction between the motor and the engine varies between ten to one and twenty-two to one. The amperage on the jump or when the starting switch is thrown in depends on the resistance opposed to revolving the engine, but will in the average case of a large four or

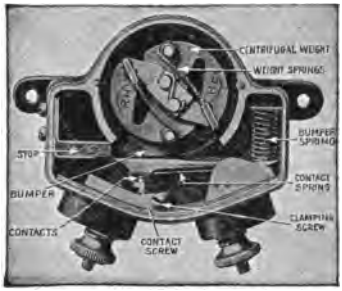


Fig. 76.—Westinghouse interrupter of ignition and lighting dynamo, showing position of interrupter parts at high speed. The interrupter is mounted on the generator shaft and the contacts are operated by a simple, rugged, centrifugal device that automatically adjusts the spark advance to the speed, keeps the period of contact nearly constant at all speeds, and prevents any inequality between the two interruptions that occur in succession during each revolution. The interrupter case is readily removable for examination, without the use of tools. The centrifugal weights are omitted and a cam substituted where automatic spark advance is not desired.

small six cylinder motor be 200 on the jump and about 80 for a running amperage. The motor is series wound and is generally geared to the flywheel; it is operated by a switch which throws the gears into engagement for starting, by first meshing them and then spinning the engine. The motor is autom tically thrown out of engagement when the engine operates under its own power.

Three Unit Systems.—This division comprises those systems which have a motor, dynamo and magneto each separate. Here, each unit has a single function and is only electrically associated with the rest of the apparatus in the system. Thus, the dynamo supplies current for charging the battery, which in

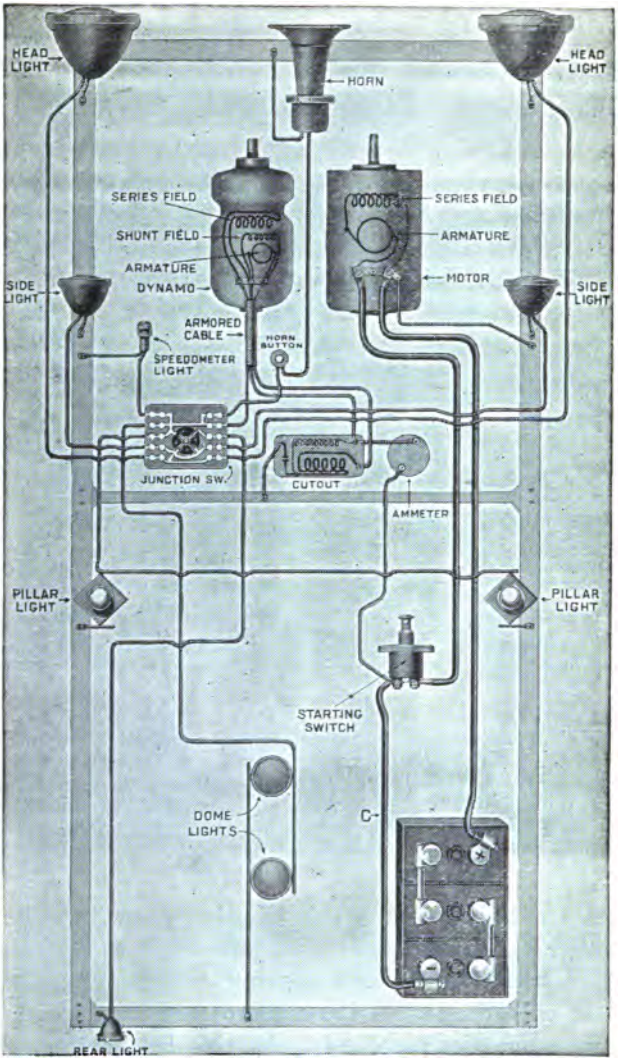


Fig. 77.—Gray and Davis system with grounded method of wiring.

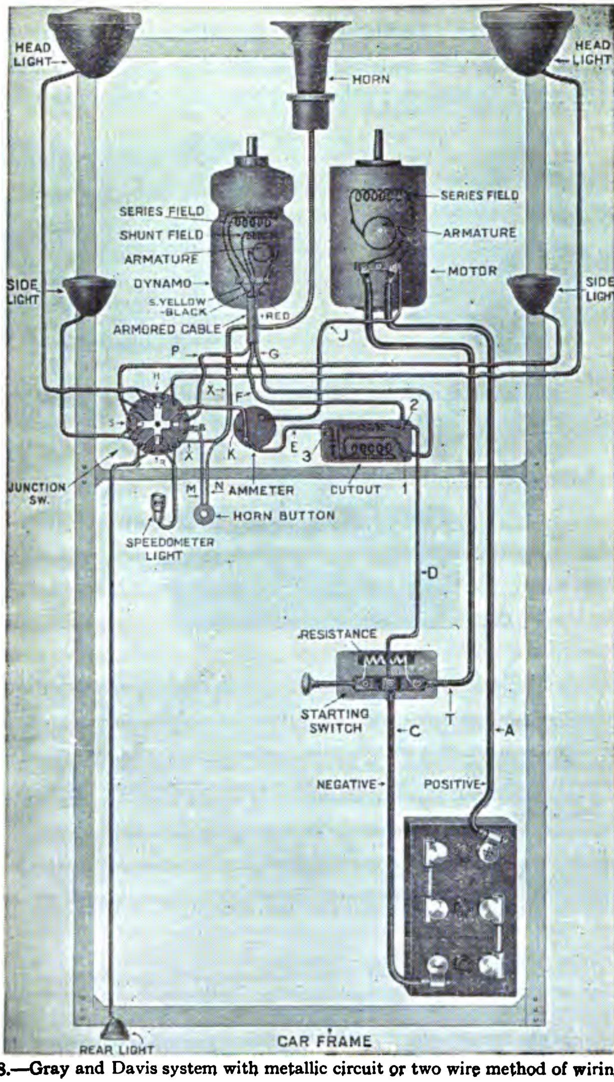


Fig. 78.—Gray and Davis system with metallic circuit or two wire method of wiring.

turn delivers current to the motor and ignition system at starting, and also to the lighting system, the magneto furnishing current for the ignition system, when the engine is running.

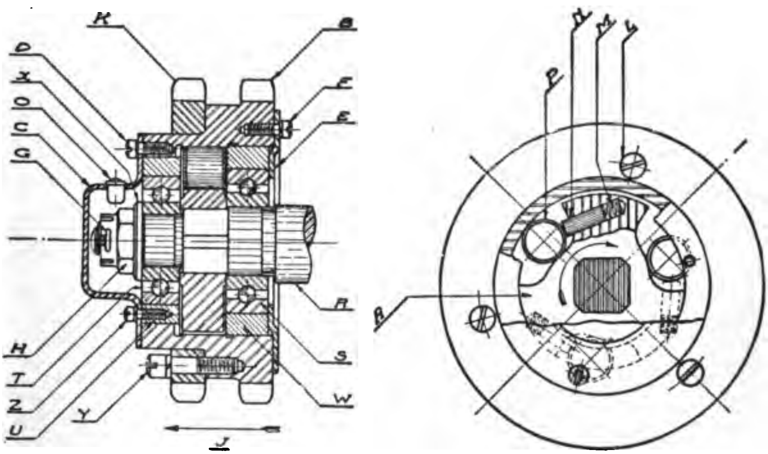
FIG. 79.—Gray and Davis grounded system junction switch which serves as a common center for all lighting circuits and to control head, side, and rear lamps from one base.

FIG. 80.—Reverse side of grounded system junction switch, showing the bus bars and fuses in position. Two emergency fuses will be noted at the top in clips.

FIG. 81.—View of cut out connections, of Gray and Davis system. The cutout consists of an electro-magnet having two windings, *the shunt winding* of fine wire is in series with the heavy winding, and terminates at terminals 1 and 2, *the series* winding of heavy wire terminates at terminals 1 and 3 when the contact points are closed. Both windings are wound on a soft iron magnet core. The shunt, or fine winding, is permanently in circuit with dynamo so that when dynamo reaches a predetermined charging speed sufficient current passes through winding to energize core, which attracts cut out armature and closes contact points, permitting current to pass from dynamo through cut out series winding to system. The magnetizing influence of series winding is added to that of shunt winding, holding contact points firmly together. When dynamo speed drops below charging requirements, current flows from battery through cut out series winding in reverse direction. This weakens the pull and allows spring to open contact points, thereby disconnecting dynamo from system. The cut out should be placed horizontally (preferably on dash) with armature at under side, but if vertical position be necessary, place with contact points downward. To determine if cut out be functioning properly, see that all wires connecting dynamo, cut out, junction switch, ammeter and battery, are in firm contact and free from contact with frame of car. With engine running over 12 miles per hour, the cut out armature should close and bring contact points together. Disconnect wire from No. 1 terminal. The cutout armature should return to normal, or open position. If it act sluggishly, apply a drop of oil at pivoted end of armature. If contact points open and close in accordance with above, shunt winding is correct. To determine if series winding be functioning, turn engine at or over 12 miles per hour, and disconnect wire from No. 2. Cut out armature should remain raised. Its failure to do so indicates contact points are not in contact, or open circuit exists elsewhere in circuit. Remove wire or screw from No, 3, If armature release, series winding is functioning properly.

In the manufacture of three unit systems, some make the entire outfit, others manufacturing only motor and dynamo, leaving it optional as to the make of magneto employed.

The following description of the "Disco" will serve as an example of three unit system:



FIGS. 82 and 83.—Side and end sectional views of Gray and Davis **over running clutch.** Its office is to transmit the motion and energy of starting motor to crank shaft and *to prevent* transmission of crank shaft motion to starting motor when engine is running under its own power or is cranked by hand. **The operation of the clutch is as follows:** When the starting motor shaft is driven in a "clockwise" direction, as viewed from clutch end, the rolls within sprocket housing slide into the wedge angles between the curved surfaces of the centerpiece and the race surface of the driving sprocket until the race surface pressure is sufficient to cause sprocket to be driven by action thus established. The springs, back of the pins, acting on the rolls keep the latter firmly within wedge angles at all times, so that they grip sprocket as soon as starting motor shaft turns. As soon as engine spins faster than motor, rolls are released from the wedge angle, permitting over running action of clutch, enabling engine to turn without any dragging effect from starting motor. To adjust clutch: Remove screws Z and D, take off retainer C; remove nut and cotter G; take off retaining washer X; remove entire clutch mechanism in direction indicated by arrow J; remove screws F; take off retainer E; take out ball bearing S; remove bushing W; note the condition of clutch parts.

The motor and dynamo are both of the same size, each operating at 12 volts. The aluminum cases are interchangeable for each unit, the entire difference being in the windings, which are simple series on the motor and compound on the dynamo.

The dynamo does not come into action until the speed of the engine has reached the point at which the car is traveling seven miles per hour. Below this point a cut out switch prevents any connection between the storage battery and the generator, and eliminates any possibility of a discharge to the generator.

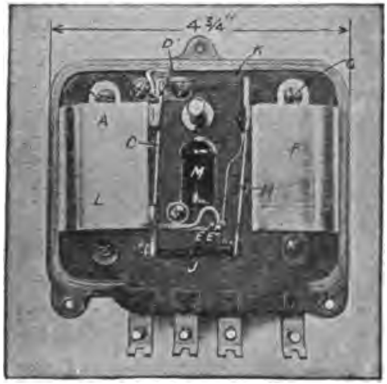


FIG. 84.—Ward Leonard automatic controller for automatically regulating the charging of the battery. When the car speed becomes approximately seven miles per hour, the dynamo armature will give a voltage sufficient to charge the batteries. The circuit between the dynamo and the batteries is normally open, but when the voltage of the dynamo becomes proper for charging, the coil A on the magnet core B, magnetizes the core sufficiently to attract the arm C. This arm moves toward the core B and thus two spark proof points D D' are brought together, establishing the circuit between the battery and the dynamo, and the dynamo begins to charge the batteries. In a dynamo the dynamo voltage increases with the speed unless a method of controlling it is adopted. The dynamo should charge at about seven miles per hour, but it is desirable that when the car runs at a much higher speed, as 15 to 60 miles per hour, the dynamo voltage shall not increase. If allowed to increase, such an excessive dynamo voltage would tend to cause sparking at the brushes, excess current and consequent trouble at the commutator and excessive wear and heating of the bearings. It would also cause an excessive amount of current to flow through the battery. To prevent this, the strength of the dynamo field, and consequently the output of the dynamo, is made dependent on the touching of the two points E E'. The coil F on the magnet core G carries the armature current, and if this current become a certain amount (usually in practice 10 amperes) the core becomes sufficiently magnetized to attract the finger H. This separates the contacts E E' and a resistance M is inserted in the field circuit, weakening it. This causes the amperes flowing through the battery to decrease. When the current decreases to a predetermined amount (say 9 amperes), the coil F does not magnetize the core G enough to overcome the pull of the spring J. The spring J pulls together the points E E', the full field strength is restored and the current tends to increase. Under operating conditions, the finger H vibrates so rapidly as to keep the current constant. As a result the dynamo will never charge above a predetermined amount (10 amperes), no matter how high the speed of the car, but at all speeds greater than a predetermined speed (about 15 miles per hour in practice), the dynamo will charge at a varying rate, which has a maximum of 10 amperes and a minimum of 9 amperes. In case the engine speed become so low that the dynamo cannot charge the battery, the magnetism caused by the coil A is weakened so that the spring K pulls the contacts DD' apart. Thus the circuit between the dynamo and battery is opened when the dynamo speed is too low for the dynamo to charge. The auxiliary series coil L on core B acts to insure the perfect demagnetization of the core B on reversal of current.

Below seven miles an hour the lighting current is drawn from the battery, which may be in any size desired over an 80 ampere hour capacity. The upper limit to the charging point is about 25 miles an hour. Above this the dynamo is again cut out and has no connection with the storage battery.

The motor generally is mounted so as to drive through teeth cut on the periphery on the flywheel, or it may be mounted on the one end of the engine or the gearset. A roller clutch is used which cuts out the motor as soon as the engine starts.

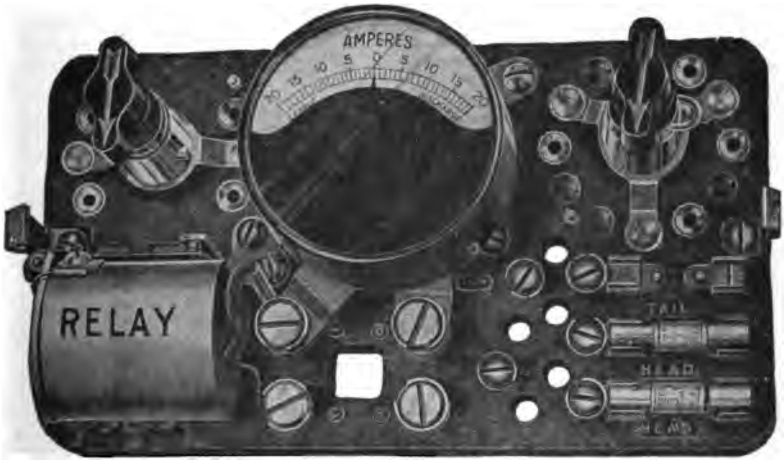
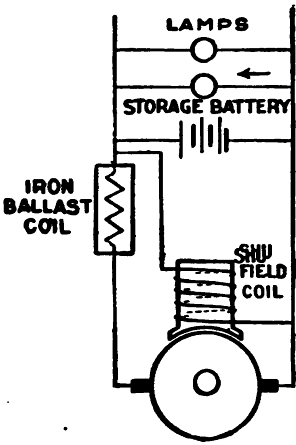
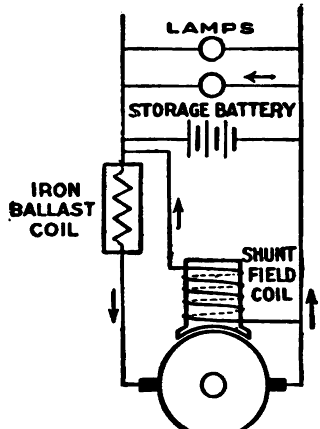


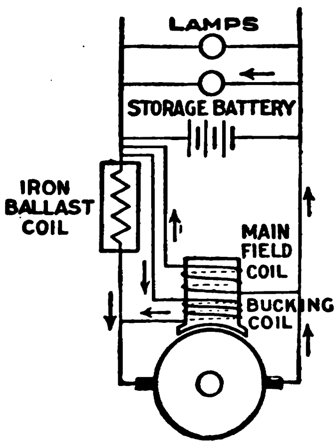
FIG. 85.—**National** dash unit with cover removed. The reverse current relay consists of a relay blade, electromagnet, contact points, and hammer stroke spring which prevents the contact points sticking. Trouble in one individual circuit will not affect the other parts of the lighting or ignition system and by removing the fuse from any circuit which is defective, it will temporarily cut that particular circuit out of use until repairs can be made. In installing the dash unit which includes the ignition and lighting switches, ammeter and relay, it is only necessary to bore two holes through the dash for the stud bolts and the necessary holes for wires.

When the driver pushes in his switch, closing the circuit between the battery and the motor, the latter will turn the crankshaft until the engine picks up its own cycle, allowing the motor to come to rest.

Methods of Control.—In any electric system where there is a dynamo and a storage battery, two control elements are necessary for the proper working of the system:





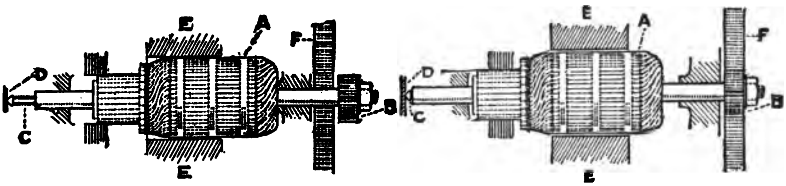


FIGS. 86 to 88.—Method of obtaining self-regulation in the Rushmore lighting system. As a current of constant volume is desired, it follows that self-regulation must be produced by change in the volume of current rather than in the voltage. The first clue to the solution of the problem was found in a peculiar property by iron, of increasing greatly in electrical resistance at a certain critical temperature just below the red heat. Below this "critical" point the resistance is practically constant. At and beyond the critical temperature, the resistance increases enormously with each degree of temperature increase. Starting from this peculiar property of iron, the next thing was to employ it correctly. The primitive method would have been to insert a thin coil of iron wire directly in the circuit and simply waste the surplus energy at higher speeds in heat as shown in fig. 86. This however, would have given very imperfect regulation, besides necessitating a heavy and clumsy machine, since the shunt field winding would receive the full voltage normal to the speed at any moment. To keep down the strength of the current in the shunt field coil one terminal of the latter may be connected beyond the iron "ballast" coil instead of between that and the armature and the "ballast" coil as in fig. 87. With this arrangement better results are obtained, but, as the field excitation remains constant, an excessive voltage will still be generated at high speeds.

1. Means for preventing reversal of current when the dynamo is charging the battery;

2. Means for limiting the dynamo voltage.

When the dynamo is charging the battery, if its speed be reduced beyond a certain point, as by slow running of the car, the pressure induced in its armature will become *less* than the battery pressure against which it must force the current to charge the latter. Unless some automatic device be provided to break the circuit when such condition obtains, the current



FIGS. 89 and 90.—Operation of Rushmore starter. The armature A is normally held out of line with the pole pieces EE by a compression spring C in the commutator end of the shaft. In this position the pinion is out of mesh with the flywheel gear F. When the switch is closed the armature is sucked endwise with great force by the attraction of the pole pieces into its working position, thereby engaging the pinion B and setting the flywheel in motion; fig. 90. To hold the armature in position against the pressure of the spring, it is made a little longer than the pole pieces, so that a certain amount of end pull is exerted while the armature is turning. The instant the engine starts, the motor is relieved of its load and the current drops almost to nothing, so that the spring automatically pushes the armature and pinion out of action before the speed has time to increase appreciably; fig. 89. Thereafter, the current required to spin the armature without load is too small to attract the armature back into its working position, hence it spins idly till the switch button is released. As the pinion goes out of mesh the instant its work is done, the whole action is practically noiseless, and no skill whatever is demanded of the operator. To facilitate engagement, the switch is given two active contacts. The first contact partially short circuits the armature, so that it rotates only enough to make sure that the pinion will slip easily into mesh. The last contact puts the motor in action and cuts out a resistance in the main circuit. The switch arm is opposed by a spring with sufficient stiffness to insure that the movement shall not be too abrupt; in other words, the operator does the right thing without having to think about it. On the return motion the switch arm jumps the first or short circuiting contact.

will reverse and flow out of the battery. The mechanism usually employed to prevent such action is called a **discriminating cut out,** or **reverse current circuit breaker.**

It consists of an electromagnet connected in the dynamo circuit, which, when the dynamo generates sufficient to charge

the battery, will attract an armature and close the circuit between the dynamo and battery, and which will also open the circuit when the battery pressure becomes greater than that induced in the dynamo. The construction of such device is shown in the accompanying cuts.

In the operation of a dynamo the greater the speed, the greater the output, but in charging a battery it is essential that the voltage do not exceed a certain maximum, so that the charging rates

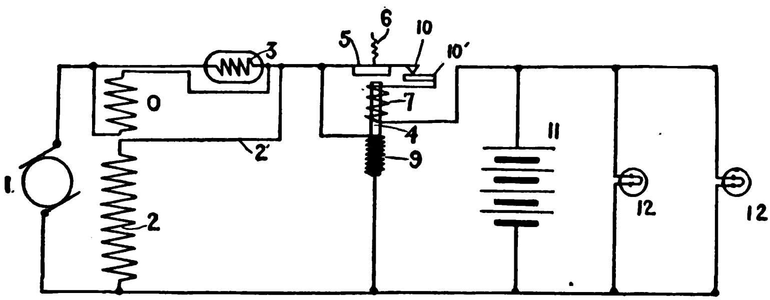


FIG. 91.—Diagram showing circuit connection of **Rushmore** dynamo with automatic cut out. The construction of the cut out is shown on fig. 93. The shunt field coil is connected beyond the ballast coil so that it receives current at all times at the constant voltage of the battery, and another winding is added to the field. This is what electricians call a "bucking" coil, that is a coil so connected as to *oppose* the main shunt field coil. This bucking coil, the effect of which is to reduce the field excitation, is connected as a shunt across the iron ballast coil. Its resistance is considerably greater than that of the ballast coil when the latter is cold or only warm, so that at low engine speeds practically all of the current generated passes directly to the battery and lamps and the machine acts as a simple unhampered shunt dynamo. However, the iron wire will allow only a certain number of amperes to pass, after which it suddenly increases in resistance, so that any excess current cannot pass, but must go through the field bucking coil which thus, only at high speeds, comes into action and chokes down the dynamo excitation. It will thus be seen that the output of the dynamo may be adjusted to any value desired by simply employing an iron wire of suitable diameter in the ballast coil. At car speeds below 15 miles an hour the dynamo acts as a simple uncontrolled shunt wound machine, while at the higher speeds, owing to the counter effect of the bucking coil, the resultant excitation is less than the excitation due to the main shunt field coil alone. In order to keep the current in the main shunt field coil as nearly constant as possible, it is connected at a point beyond the ballast coil instead of directly across the brushes; then it does not feel the fluctuations of voltage at the brushes. The effect of controlling the bucking coil by the current output is to produce an approximately constant current at the higher speeds. The voltage is determined by the storage battery, and is simply the voltage required to force the specified current against the reverse pressure, plus the small internal resistance of the battery. Assuming the battery to be in good condition, the dynamo voltage will be slightly in excess of the open curcuit voltage of the battery, from about 6¼ to 6½ volts, depending upon the state of charge. The battery is necessary to control the voltage of any automobile lighting dynamo, and must never be disconnected therefrom while the dynamo is in use.

do not become higher than that proper for the battery. Hence automatic control of the voltage is necessary.

FIG. 92.—Rushmore ballast coil with cover removed to show the iron wire illustrated full size.

There are several ways of effecting this regulation:

1. Mechanically;
2. Electrically;
3. Thermally.

FIG. 93.—Automatic cut out as used for Rushmore electric car lighting system.

An example of mechanical control is the Gray & Davis system, where a clutch and centrifugal governor are used.

The Ward-Leonard has electromagnet control, and in the Westinghouse there are two electrical fields, which oppose one another as the speed of the dynamo increases. The Rushmore system furnishes an example of thermal control.

ELECTRICITY

The term electricity is derived from the Greek word electron—amber. It was discovered more than 2,000 years ago that amber when rubbed with an ox's tail possessed the curious property of attracting light bodies. It was discovered afterwards that this property could be produced in a dry steam jet by friction, and afterwards, that glass, sealing wax, etc., were also affected by rubbing, producing electricity.

Answers Relating to Electricity

Ques. What is electricity?

Ans. The name given to an invisible agent known only by its effects and manifestations, as shown in electrical phenomena.

Ques. Is there more than one kind of electricity?

Ans. Electricity, no matter how produced, is believed to be one and the same thing. The terms frictional electricity, magneto electricity, etc., though convenient for distinguishing their origin, have no longer the significance formerly attributed to them as representing different kinds of electric force.

Ques. How are the units of electricity expressed?

Ans. These are stated in terms of length, weight and time, which is to say in terms of centimeters, grams, and seconds. The units thus established are largely arbitrary,

but they have been carefully estimated, so that the proportions between current strength, circuit resistance and voltage may be accurately maintained.

Ques. What is an ohm?

Ans. The unit of resistance. It is named for G. S. Ohm, the German scientist, and is equal to the resistance offered to an unvarying electric current by a column of mercury at 32° Fahr., 14.4521 grams in mass, of a constant cross sectional area, and of the length of 106.3 centimeters.

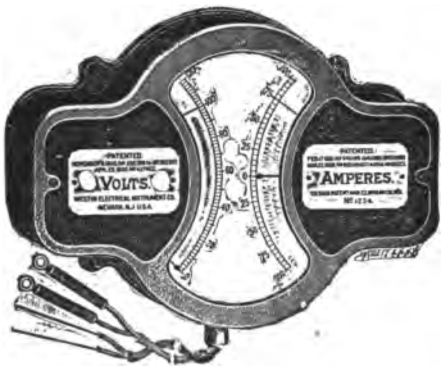


Fig. 94.—Western volt-ammeter of the type used on electric vehicles. Other makes have the index scales side by side, instead of end to end.

The ohm measures not only the relative resistance of a circuit composed of a conducting wire of a given length and diameter, as compared with wires of different lengths and diameters composed of the same material, but also the specific resistance, which refers to the variations in resistance found between given wires of the same length and cross section, made of different materials. The different resistivity of several different metals, as found in circuits of similar dimensions, is demonstrated by the fact that, while a unit wire of silver shows a conductivity of 100, and one of copper 99, a wire of iron gives only 16.80.

Ques. What is an ampere?

Ans. The unit of current. An ampere is the current produced by an electromotive force of one volt in a circuit

having a resistance of one ohm, it is that quantity of electricity which will deposit .005084 gram of copper per second.

Ques. What is a volt?

Ans. The unit of pressure or electromotive force. A volt is that electromotive force which can produce a current of one ampere on a circuit having a resistance of one ohm.

There are several specified equivalents for estimating the exact value of one volt E. M. F., but these usually refer to the determined capacity of some given type of galvanic cell. It is sufficient to say, however, for ordinary purposes, the majority of commercial chemical cells are constructed to yield approximately one volt. The ordinary Daniell cell used in telegraphy has a capacity of 1.08 volt, and the common type of Leclanche cell gives about 1.50.

Ques. What are the mutual relations between the ampere, the volt and the ohm?

Ans. The current in amperes equals the pressure in volts divided by the resistance.

Expressed as a formula:

$$\text{Amperes} = \frac{\text{volts}}{\text{resistance}}, \text{ or using the usual symbols}$$

$$C = \frac{E}{R} \qquad (1)$$

from (1) is obtained

$$E = C\,R \qquad (2)$$

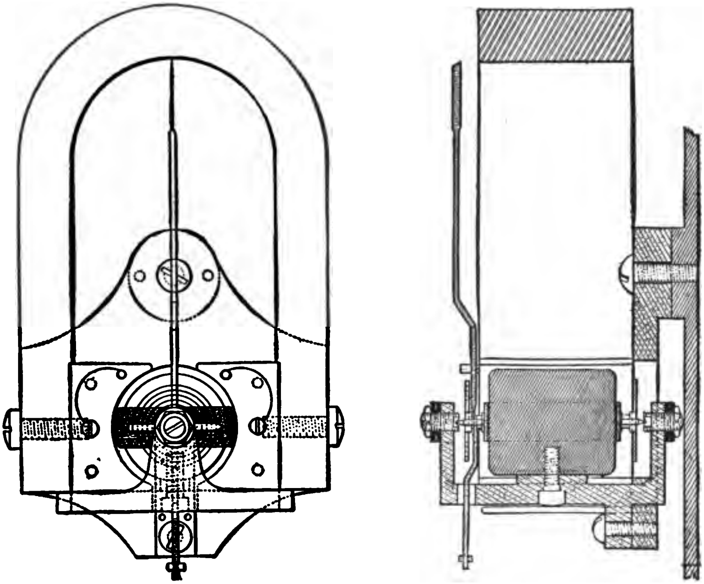
$$R = \frac{E}{C} \qquad (3)$$

If one volt will force one ampere of current through a circuit having one ohm resistance, it will take five volts to force five amperes through the same circuit. If this resistance be increased to five ohms, it would take five times five amperes for the proper number of volts to force the amperes through, which would be twenty-five volts. From this it can be seen that it is easy to obtain any one of these quantities when the other two are known.

Ques. What is a watt?

Ans. The unit of power. It is the rate of energy of one ampere of current under a pressure of one volt, and is approximately equal to $\frac{1}{746}$ horse power.

The watt derives its name from James Watt, the English engineer.



Figs. 95 and 96.—Sectional diagrams illustrating the construction of volt meters and ammeters. The iron core is secured to the base plate by a screw. The active coil is shown wound around it from end to end.

Ques. What is an electrical horse power?

Ans. The electrical equivalent of 33,000 foot pounds per minute or 746 watts.

To obtain the electrical horse power, as for instance the power developed by a motor, the product of the volts and amperes is divided by 746, that is,

$$\text{E. H. P.} = \frac{\text{volts x amperes}}{746}$$

Ques. What is the general construction of volt meters and ammeters?

Ans. Electrical gauges for measuring volts and amperes are constructed on the principle of the D'Arsonval galvanometer, with either a permanent or a variable field. The general features are a small oscillating solenoid whose core is mounted on jeweled bearings, arranged like a dynamo armature between the poles of a permanent horseshoe magnet, with a hand or pointer pivoted at the bearing, so

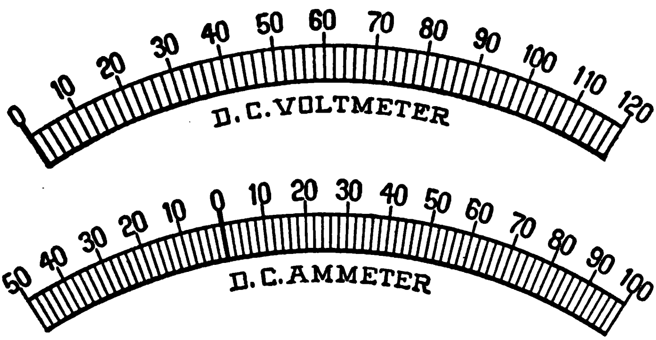


Fig. 97.—Index scales of a volt meter and ammeter for measuring the pressure and intensity of the current in a direct current electrical circuit.

as to indicate on a graduated scale the variation in electrical conditions. A coiled steel spring attached at the base of the needle acts to restrain and control its movements, thus ensuring reliable indications of current strength or intensity.

Ques. How are volt meters and ammeters arranged for automobiles?

Ans. They are usually mounted on one base, with their graduated scale cards sufficiently near together to enable rapid reading of battery conditions. These instruments frequently have the scale traced on glass, so as to be

illuminated at night by an incandescent lamp placed behind it. The voltmeter indicates the pressure between the battery terminals, while the ammeter indicates the amount of current flowing.

In running an electric vehicle, any overload that would likely damage the battery is indicated by the ammeter, when attempting to start with brakes set, or in beginning the ascent of a heavy grade from a standstill. The amount of power being consumed by the motor, is, of course, always the product of the volts by the amperes. Thus, with readings of 80 volts and 16 amperes, 1,280 watts, or about 1.7 horse power, are being constantly used.

Although the voltmeter should always register between 1.75 and 2.6 volts per cell, the former figure indicating the point of discharge—it may happen that an unusually heavy load will bring the needle temporarily below that point. Such indication does not of necessity mean that the battery is exhausted, as on coming upon a better road, it will quickly resume its normal reading.

DYNAMOS AND MOTORS

A dynamo is a machine for converting mechanical energy into electric current; a motor transforms the electric current into mechanical energy. The dynamo generator and the electric motor are similar so far as the general features of their construction are concerned. In operation, however, the motor is the reverse of the dynamo.

Answers Relating to Dynamos and Motors

Ques. What are the essential parts of a dynamo or motor?

Ans. The field magnets, pole pieces, armature, commutator or collector, and brushes.

Ques. What is the construction of the field magnets?

Ans. These are made like ordinary electromagnets, having two or any even number of opposed poles with their windings connected in series.

Ques. What are the pole pieces?

Ans. The steel end portions of the field magnets.

Ques. Describe the armature.

Ans. This consists of a metal core containing the shaft, and around which is a wire winding constructed to rotate near the poles of the field magnet.

Ques. Describe the commutator and brushes.

Ans. A commutator consists of copper bars or segments arranged side by side, forming a cylinder, and insulated from each other by sheets of mica. The commutator is mounted upon the shaft at one end of the armature with which it rotates. The conductors of the armature are so connected with the segments of the commutator that the current taken off by the brushes which bear upon the surface of the commutator is direct, although the armature generates an alternating current.

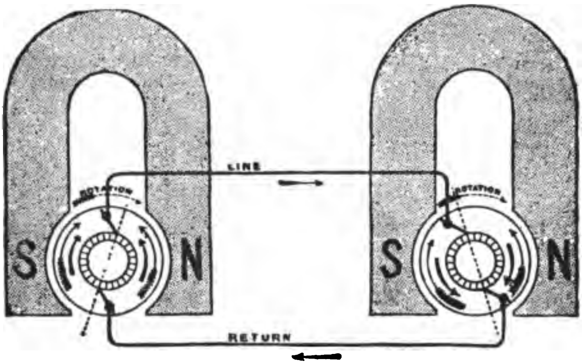


Fig. 98.—Diagram showing the operative condition of a dynamo generator and electric motor. The machine on the left is the dynamo, that on the right the motor.

Ques. What is the office of the brushes?

Ans. They bear upon the commutator and make sliding contact with the commutator bars, thus establishing the working circuits.

Ques. What type of motor is used on electric vehicles?

Ans. The kind known as series wound; this type possesses the valuable characteristic of automatically adjusting the consumption of power to the load.

Ques. How are shunt motors wound?

Ans. The field coils are on a shunt between the lead terminals.

Ques. How should the motor be operated on uneven roadway?

Ans. In hill climbing one-third and even more of the extra energy consumed can be recovered by coasting down the other side with the controller set a notch or two below the coasting speed.

While it is not necessary to be an electrician to operate an electrically driven vehicle, it is of great advantage to know what to do when certain troubles occur.

If an attempt be made to start with a single motor equipment, provided with a battery connected in different ways for the various speeds, and the vehicle and ammeter do not respond, this indicates an open circuit, which may be at one of the following points:

A. The battery contacts. They may be and often are so badly corroded as to prevent the necessary metal to metal contact.

B. The controller. A connection may be loose or the fingers may not make contact.

C. The running plug may sometimes be out or not making proper contact.

D. The motor brushes. May have dropped out or the tension may be so weak that they do not make contact.

E. The emergency switch may be open.

F. The controller should be examined last.

If the motor try to start, but the current is not sufficient, as shown by the ammeter, poor contact or weak battery may be suspected. Discharged battery will be indicated by a low voltmeter indication, but if the voltmeter indicate the normal amount, poor contact should be sought. Any contacts which are part of the electric circuit, such as binding

posts, brushes, switch jaws or controller fingers must be bright metal to metal contacts. If they be dirty or corroded the contact may be so bad that the flow of current is seriously reduced or interrupted altogether.

Answers Relating to Motor Troubles

Ques. What may be said respecting improper connections?

Ans. Sometimes the absence of ampere indication and no motion of the vehicle point to improper connection of the batteries. This will be shown by heavy sparks at the controller.

When the battery is not properly connected, the motion of the controller causes the sections of battery to exchange current between themselves at a ruinous rate. The terminals of the cells and those to which they should be connected ought to be plainly marked, or, better still, so constructed that it is impossible to go wrong. If the trouble just cited be the fact, one or more sets of terminals of the cells will be found to be connected to the wrong wires.

Ques. If the vehicle fail to move, and the flow of current, as indicated by the ammeter, be considerable, what should be done?

Ans. The current should be shut off at once, as serious damage may result if this be not done. It should then be ascertained if the brakes be on, the vehicle stalled or blocked, or if there be some obstacle between the gear teeth.

Ques. What may be said of short circuits?

Ans. If a large current be indicated, and the motor remain inert, the trouble is electrical, and the inference is that the current does not go through the motor at all. To confirm this, one of the motor brushes should be lifted, and the vehicle again tried. If the large current be still indicated, the inference of a short circuit becomes a certainty.

In locating a short circuit:

1. The controller should be examined for:

A. Foreign pieces of metal making contact between portions of the electrical circuit.

B. Loose fingers which may make contact with wrong parts of the controller or with each other.

C. Dirt between the fingers or contacts.

D. Breaks in the insulation permitting the wires to make contact with adjacent metal or with each other.

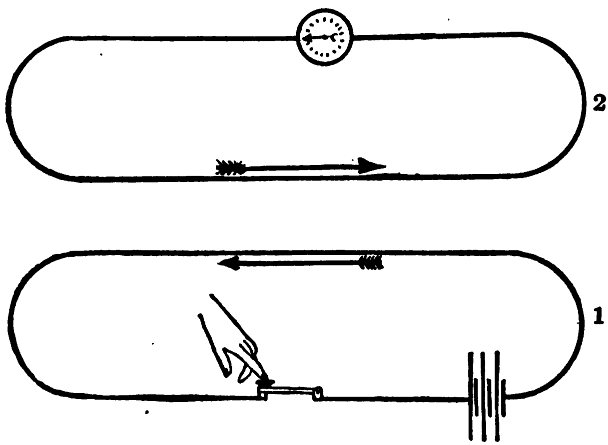


Fig. 99.—Diagram illustrating the action of voltaic induction between two circuits: the one including a source of electrical energy and a switch; the other including a galvanometer, but having no cell or other electrical source. The direction of the battery current in circuit 1 is indicated by the arrow: the arrow in circuit 2 shows the direction of the induced current.

2. The motor should be examined for:

A. Broken insulation, allowing the bare wires to touch the frame or each other.

B. Dirt between contacts or between live metal and the motor frame.

C. Foreign materials bridging contacts.

In such a case, it is sometimes of assistance to turn on the current for an instant. The defective place may be indicated by a smoke or spark.

Ques. If, when a brush is lifted and the vehicle tried, the excessive current indication should disappear, what two electrical troubles are possible?

Ans. The magnet coils of the motor may be short circuited, or the ammeter may not be reading correctly.

The latter trouble is least likely; hence the former should be sought first.

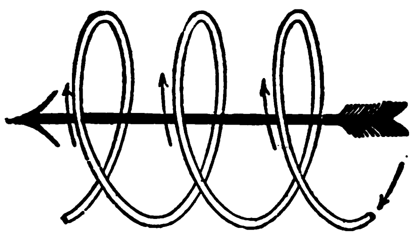


Fig. 100.—Diagram illustrating the directions of the current in the field windings and the induced current, as found in magnets, solenoids and dynamo operation.

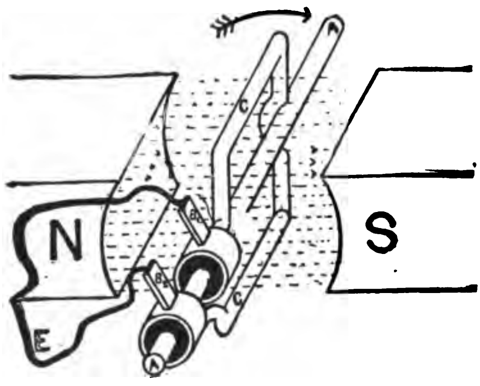


Fig. 101.—Diagram of a dynamo electrical generator, arranged for producing an alternating current, showing the constructional and operative features. Here N and S are the positive and negative poles of the field magnets, between which the lines of force are shown by the dotted lines. A is the armature spindle; B_1 and B_2, the brushes bearing on the ring drums; C, the coil or winding of the armature; E, the outside circuit to which the current is supplied.

Ques. What is the effect of a short circuited magnet coil of a series motor?

Ans. The motor will call for a large current but will do nothing with it. The magnet coils, therefore, should be examined for short circuits.

Ques. May a short circuit exist without ammeter indication?

Ans. Yes; a short circuit of this kind is usually found in the controller, which sparks heavily when operated,

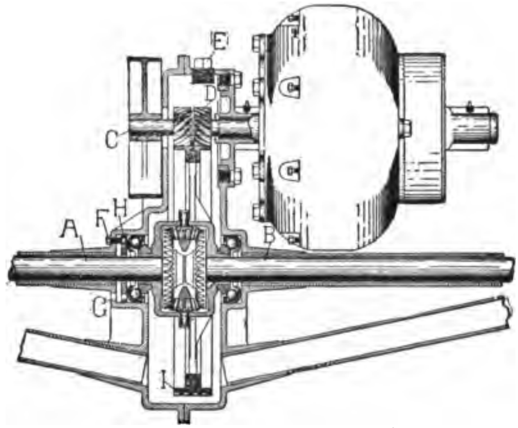


Fig. 102.—Diagram of a single motor attached to rear axle through "herringbone" single reducing gears. A, is the left hand section of the divided rear axle; B, the right hand section of the rear axle; C, the brake drum; D, the spiral pinion on the motor shaft driving the worm gear, I, on the differential; E, plug for greasing gears; F, set screw for locking ball race; G, slot for wrench to adjust threaded ring, H, against ball bearings.

although the vehicle does not move. This combination of phenomena also indicates improper connection of the batteries.

Ques. How is an excessive call for current indicated, other than by the ammeter?

Ans. A heavy current is accompanied with a drop in the voltmeter reading.

Ques. What may be said of two motor troubles?

Ans. Most difficulties which arise differ but little from those encountered with a single motor. A few which are

peculiar to this type may be mentioned. Such motors are sometimes run in two ways. The first notch connects the motors in series, while the higher speed notches connect the motors in parallel. If one of the motors open circuit on a series notch, the vehicle stops, for the entire motive circuit is broken. If it open circuit on a parallel notch, that motor stops and the other, with its circuit to the batteries intact, continues to run and may cause the vehicle to make some abrupt and unexpected turns.

If the accident occur in a series notch, the unimpaired motor continues to run, and, it may be added, at nearly double its previous speed. If it occur on a parallel notch, a short circuit on one motor constitutes a short circuit on the other also, and if the short circuit be sufficiently severe both motors will stop, even though an enormous current may be drawn from the batteries.

STORAGE BATTERIES

Storage batteries are devices for storing electric energy, which may be utilized subsequently for various purposes. The term accumulator is sometimes applied from the fact that they "accumulate" electric energy when charged from an outside source. Storage batteries are also called secondary batteries to distinguish them from those of the primary type.

Secondary batteries are in no sense generators of electricity, but are employed to accumulate a given quantity of electric energy, the quantity of which is estimated by the number of hours required to discharge it at a given rate.

Answers Relating to Storage Batteries

Ques. Describe the action of a storage cell.

Ans. Gautherot discovered that if two plates of platinum or silver, immersed in a suitable electrolyte, be connected to the terminals of an active primary cell and current be allowed to flow, a small current could be obtained on an outside circuit connecting these two electrodes, as soon as the primary battery had been disconnected.

Ques. Explain the process in detail.

Ans. An electrolyte, consisting of a weak solution of sulphuric acid, permits ready conduction of the current

from the primary battery; the greater the proportion of acid within certain limits the smaller the resistance offered. The effect of the current passing through the electrolyte is to decompose the water; this is indicated by the formation of bubbles upon the exposed surfaces of both electrode sheets, these bubbles being formed by oxygen gas on the plate connected to the positive pole of the primary battery and hydrogen on the plate connected to the negative pole of the battery. Since, however, the oxygen is unable to attack either platinum or silver under such conditions, the capacity of such a device to act as an electrical accumulator is practically limited to the point at which both plates are covered with bubbles. After this point has been reached the gases will begin to escape into the atmosphere.

Ques. What is the prime condition for operation in the simpler apparatus just described?

Ans. The resistance of the electrolyte should be as low as possible in order that the current may pass freely and with full effect between the electrodes. If the resistance of the electrolyte be too small, the current intensity will cause the water to boil rather than to cause the electrolytic effects noted above.

Ques. What happens when the charging current is discontinued, and the two electrodes joined by an outside wire?

Ans. A small current will flow as a result of the recomposition of the acid and water solution. The process is in a very definite sense a reversal of that by which the current is generated in a primary cell. Hydrogen collected upon the negative plate, which was the cathode, so long as the primary battery was in circuit, is given off to the liquid immediately surrounding it, uniting with its particles of oxygen and causing the hydrogen in combination with them to unite with the particles of oxygen next adjacent,

continuing the process until the opposite positive plate is reached when the oxygen collected there is finally combined with the surplus hydrogen, going to it from the surrounding solution.

This chemical process causes the current to emerge from the positive plate, which was the anode, so long as the primary battery was in the circuit. The current thus produced will continue until the recomposition of the gases is complete, then ceasing because these gases, as before stated, do not combine with the metal of the electrodes.

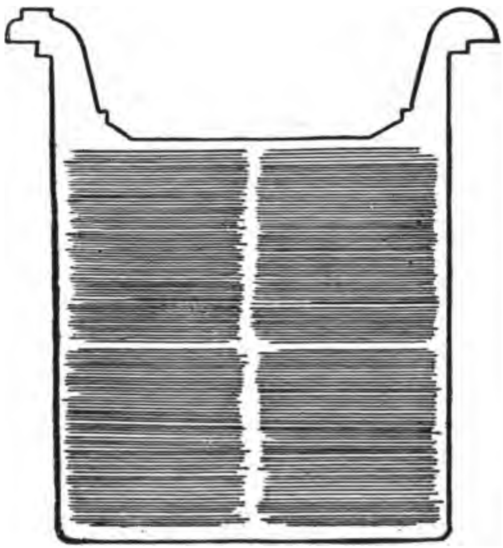


Fig. 103.—"Unformed" plate of one pattern of Gould storage cell. The particular plate shown has total outside dimensions of 6x6 inches. The clear outline of the grooves indicates absence of oxides, due to action of "forming" solutions, or charging current.

Ques. What material is used for the plates?

Ans. Batteries are manufactured with plates made of iron and nickel, lead and zinc, and lead and lead, the latter being extensively used. The choice of material depends largely upon the service required of the battery.

In lead batteries, the negative plates are made of sponge lead which has a light gray color and is very soft. The positive plates are of peroxide of lead, being dull chocolate in color and hard in texture.

Ques. Name two classes of storage battery.

Ans. The Plante, and the Faure.

Ques. What feature distinguishes the two types?

Ans. The difference is principally in the method of constructing the plates.

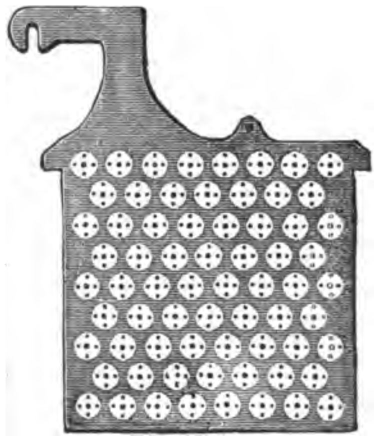


Fig. 104.—One plate or "grid" of a type of storage cell constructed by inserting buttons or ribbons of the proper chemical substances in perforations. Some such cells use crimped ribbons of metallic lead for inserting in the perforations, others pure red lead or other suitable material.

Ques. Describe the Plante type.

Ans. In the Plante type the lead is chemically attacked and finally converted into lead peroxide, probably after it has gone through several intermediate changes. The plates are all formed as positive plates first and then all that are intended for negative plates are reversed, the peroxide being changed into sponge lead.

Ques. What is done to make the Plante plate more efficient?

Ans. The surfaces are finely subdivided, the following methods being those most common: scoring, grooving, casting, laminating, pressing and by the use of a lead wool.

Ques. Describe the Faure or pasted type.

Ans. This form of plate is constructed by attaching the active material by some mechanical means to the grid proper. The active material first used for this purpose was red lead, which was reduced in a short time to lead peroxide when connected as the positive or anode, or to spongy metallic lead when connected as the cathode or negative, thus forming plates of the same chemical compound as in the Plante type.

The materials used at the present time by the manufacturers for making this paste are largely a secret with them, but in general they consist of pulverized lead or lead oxide mixed with some liquid to make a paste.

Ques. How do Faure plates compare with those of the Plante type?

Ans. They are usually lighter and have a higher capacity, but have a tendency to shed the material from the grid, thus making the battery useless.

Many ways have been tried for mechanically holding the active material on the grid, the general method involving a special design in the shape of the grid. Some of these designs are: 1, solid perforated sheets of lattice work, 2, corrugated and solid recess plates not perforated, 3, ribbed plates with projecting portions, 4, grid cast around active material, 5, lead envelopes, and 6, triangular troughs as horizontal ribs.

Answers Relating to the Electrolyte

Ques. What solution is generally used for the electiolyte of a storage battery?

Ans. It usually consists of one part of chemically pure concentrated sulphuric acid mixed with several parts of

water. The proportion of water differs with the several types of cell from three to eight parts, as specified in the directions accompanying the cells.

Ques. What test is necessary in preparing the electrolyte?

Ans. In mixing the water and acid, the hydrometer should be used to test the specific gravity* of both the acid and the solution. The most suitable acid should show a specific gravity of about 1.760 or 66° Beaumé.

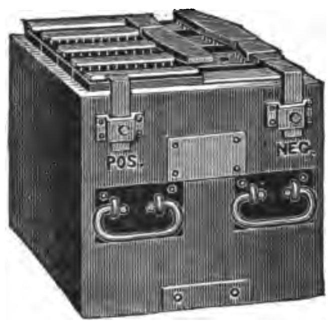


Fig. 105.—The Exide storage cell. The positive and negative plates are separated by thin sheets of perforated hard rubber, placed on both sides of each positive plate. The electrolyte and plates are contained in a hard rubber jar.

Fig. 106.—An Exide battery of five cells. The box which holds the cells is usually made of oak, properly reinforced, with the wood treated to render it acid proof. The terminals, as shown, consist of metal castings attached to the side of the box and plainly marked.

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*Note.—Specific gravity is the weight of a given substance relative to an equal *bulk* of some other substance which is taken as a standard of comparison. Water is the standard for liquids. In the laboratory the *specific gravity bottle* is often used in determining the specific gravity of a liquid. The capacity of the bottle is 1,000 grains of pure water. When it is filled with spirits of wine and weighed in a balance (together with a counterpoise for the weight of the bottle, which of course is constant), it will weigh considerably less than 1,000 grains; in fact, the bottle will contain only about 917 grains of proof spirit; therefore, taking the specific gravity of water as unity, 1 or 1.000, the specific gravity of spirits of wine is 0.917. If, on the other hand, the bottle be filled with sulphuric acid, it will weigh about 1,850 grains; hence, the specific gravity of sulphuric acid is said to be 1.850. A more convenient method for the automobilist is by the use of the hydrometer.

Ques. How should the water and acid be mixed?

Ans. The mixture should be made by pouring the acid slowly into the water, never the reverse. As cannot be too strongly stated, **it is very dangerous to pour the water into the acid**; the latter is corrosive and will painfully burn the flesh.

Distilled or rain water should be used in preparing the electrolyte. When made, the solution should be allowed to cool for several hours or until its temperature is approximately that of the atmosphere (60° being the average). At this point it should have a specific gravity of about 1.200 or 25° Beaumé. If the hydrometer show a higher reading, water may be added until the correct reading is obtained; if a lower reading, dilute acid may be added with similar intent.

The electrolyte should never be mixed in jars containing the battery plates, but preferably in stone crocks, specially prepared for the purpose. Furthermore, it should never be placed in the cell until perfectly cool.

Answers Relating to Charging

Ques. What precautions should be taken in charging?

Ans. The connections with the generator should be properly arranged that is, the positive pole of the generator should be invariably connected to the positive pole of the secondary battery, which is to say, the pole which is positive in action when the current is emerging from the secondary battery or the pole that is connected to the positive plates. An error in making the connections **will result in entire derangement of the battery** and its ultimate destruction.

Ques. How should a battery be charged for the first time?

Ans. It is essential that the current be allowed to enter at the positive pole at about one-half the usual charging rate prescribed; but after making sure that all necessary conditions have been fulfilled, it is possible to raise the

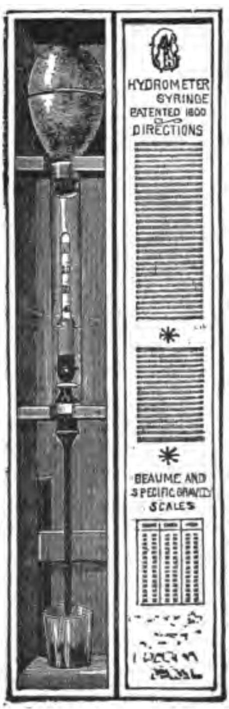
rate to that prescribed by the manufacturers of the particular battery.

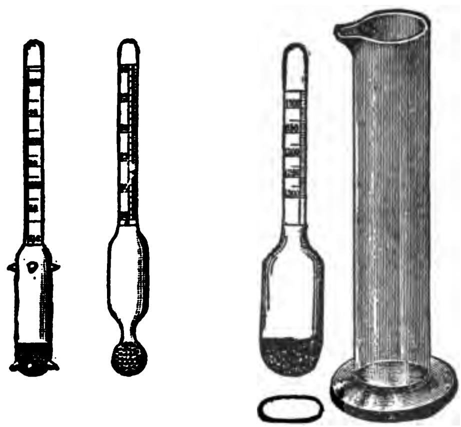
Ques. What portable instruments should be provided for testing batteries?

Ans. 1, a hydrometer syringe (specific gravity tester) 2, an acid testing set (can be used instead of the syringe), 3, a low reading voltmeter, 4, suitable prods, and 5, a thermometer.

Ques. What is the usual period for charging a new battery?

Ans. With several of the best known makes of storage battery, the prescribed period for the first charge varies between twenty and thirty hours.





Figs. 107 to 109.—Acid hydrometers for liquids heavier than water. Fig. 107, standard storage battery hydrometer with guiding points designed for "hydrometer syringe," shot bulb, with red line at 25 Beaumé, 5 inches long, double scale 10 to 40 Beaumé, 1.050 to 1.400 specific gravity. Fig. 108, plain hydrometer with shot bulb, 5 inches long, double scale 10 to 40 Beaumé, 1.050 to 1.400 specific gravity. Fig. 109, hydrometer with small flat bulb, used in car lighting batteries, shot bulb 4½ inches long, single scale, reading from 1.100 to 1.250 specific gravity. At the right is shown a jar for hydrometers.

At the first charging of a cell, when the pressure has reached the required limit, the cell should be discharged until the voltage has fallen to about two-thirds normal pressure, when the cell should again be recharged to the normal voltage (2.5 or 2.6 volts).

The manufacturers of a well known cell of the Plante genus prescribe for the first charge, half rate for four hours, after which the current may be increased to the normal power and continued for twenty hours successively.

Ques. What strength of current should be used in charging a cell?

Ans. It should be in proportion to the ampere hour capacity of the cell.

Thus, as given by several manufacturers and other authorities, the normal charging rate for a cell of 40 ampere hours should be fifty amperes; or one-eighth of its ampere hour rating in amperes of charging current.

Ques. What should be the voltage of the charging current before closing the charging circuit?

Ans. The voltage should be at least ten per cent. higher than the normal voltage of the battery when charged.

Ques. What indicates the completion of a charge?

Ans. When a cell is fully charged the electrolyte apparently boils and gives off gas freely. The completion of a charge may also be determined by the voltmeter, which will show whether the normal pressure has been attained.

Ques. How should the voltage be regulated during the first charge?

Ans. It should be allowed to rise somewhat above the point of normal pressure.

Ques. How often should a battery be charged?

Ans. At least once in two weeks, even if the use be only slight in proportion to the output capacity.

In charging a storage battery, it is essential to remember the fact that the normal charging rate is in proportion to the voltage of the battery itself.

Thus, a 100 ampere-hour battery, charged from a 110 volt circuit at the rate of ten amperes per hour, would require ten hours to charge, and would consume in that time an amount of electrical energy represented by the product of 110 (voltage) by 10 (amperes) which would give 1,100 watts.

Ques. What precaution should be taken in charging a battery?

Ans. Care should be taken not to have a naked flame anywhere in its vicinity.

To either charge or discharge a battery at too rapid a rate involves the generation of heat. Thus, while this is not liable to result in a flame under usual conditions, the battery may take fire, if it be improperly connected or improperly used.

Ques. How is the electrolyte affected by the first charge?

Ans. A change of specific gravity occurs. The specific gravity should be about 1.200 when the solution is first poured into the cells.

At the completion of the first charge, it should, on the same scale, be about 1.225. If it be higher than this, water should be added to the solution until the proper figure is reached, if it be lower, dilute sulphuric acid should be added until the hydrometer registers 1.225.

Ques. What is the effect of varying the charging current?

Ans. In charging a storage cell, particularly for the first time, a weaker current than that specified may be used with the same result, provided the prescribed duration of the charge be proportionally lengthened. The battery may also be occasionally charged beyond the prescribed voltage, ten or twenty per cent. overcharge effecting no injury, although, if frequently repeated, it shortens the life of the battery.

Ques. What are the charge indications?

Ans. The state of the charge is not only indicated by the density of the electrolyte and the voltage of the cell, but also by the **color of the plates,** which is considered by many authorities as one of the best tests for ascertaining the condition of a battery.

Ques. What are the colors of the plates?

Ans. In the case of formed plates, and before the first charging, the positives are of a dark brown color with whitish or reddish gray spots and the negatives are of a yellowish

gray. The whitish or reddish gray spots on the positive plates are small particles of lead sulphate which have not been reduced to lead peroxide during the process of forming, and represent **imperfect sulphation.**

As a general rule, the first charging should be carried on until these spots completely disappear. After this the positive plates should be of a dark red or chocolate color at the end of the discharge, and of a wet slate or nearly black color when fully charged. A very small discharge is sufficient, however, to change them from black to the dark red or chocolate color.

If the battery has been discharged to a potential lower than 1.8 volts, the white sulphate deposits will reappear, turning the dark red color to a grayish tint in patches or all over the face of the plate, or in the form of scales of a venetian red color.

The formation of these scales while charging indicates that the maximum charging current is too large and should be reduced until the scales or white deposits fall off or disappear, after which the current can be increased again.

During charging, the yellowish gray color of the negatives changes to a pale slate color which grows slightly darker at the completion of the charge. The color of the negatives always remains, however, much lighter than that of the positives.

Ques. How is the discharge capacity of a storage battery stated?

Ans. In ampere hours. This, unless otherwise specified, refers to its output of current at the eight hour rate. Most manufacturers of automobile batteries specify only the amperage of the discharge at three and four hours. Thus, at the eight hour rate, a cell which will discharge at ten amperes for eight hours is said to have a capacity of eighty ampere hours. It does not follow that eighty amperes would be secured if the cell were discharged in one hour. It is safe to say that not more than forty amperes would be the result with this rapid discharge.

Ques. How does the capacity decrease?

Ans. The ampere hour capacity decreases with the increase in current output.

An 80 ampere-hour cell, capable of delivering 10 amperes for 8 hours, would, when discharged at 14 amperes, have a capacity of 70 ampere hours; when discharged at 20, its capacity would be

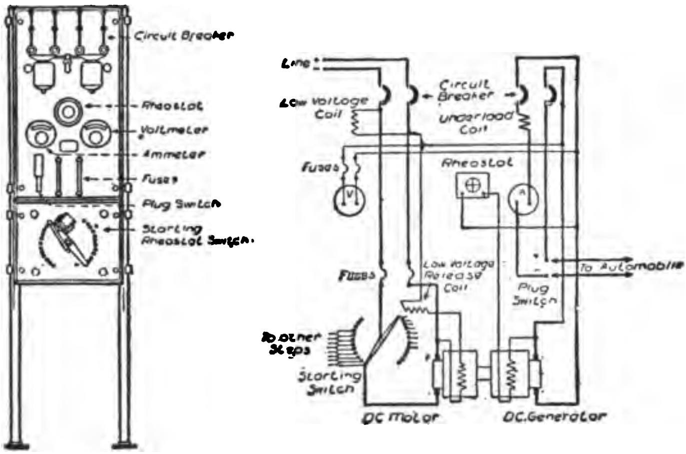
60; and when discharged at 40, its capacity will have decreased from 80 to 40 ampere hours.

Ques. What, in general, is the indication of the quantity of electricity remaining within a cell?

Ans. The voltage.

Ques. What should be noted by the operator in driving a car?

Ans. He should bear in mind the figures supplied by the manufacturers of the type of battery he uses, in order to judge: 1, how long the charge will last, and 2, whether



Figs. 110 and 111. Switchboard and motor generator circuit connections for charging a battery from direct current mains.

he is exceeding the normal rate of discharge, and thus contributing to the unnecessary waste of his battery and incurring other dangers that may involve unnecessary expense.

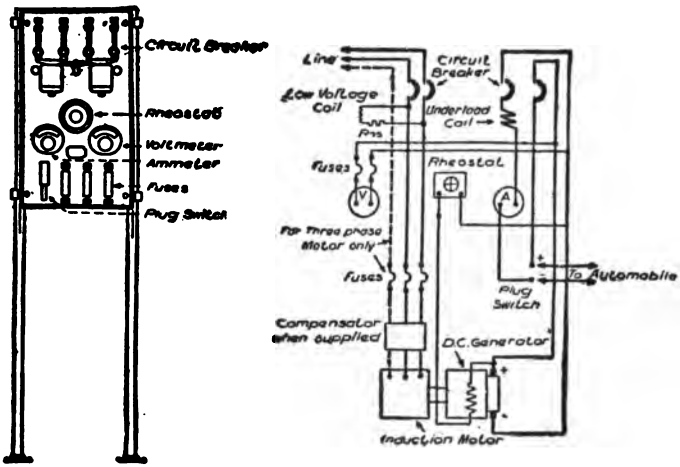
As a general rule, the one hour discharge rate is four times that of the normal, or eight hour discharge, and considerations of economy and prudence suggest that it should never be exceeded, if, indeed, it be ever employed. The three hour discharge, which is normally twice that of the eight hour, is usually the highest that is prudent, while the four hour discharge is the one most often employed for the average high speed riding; batteries give only the three and four hour discharge rates in specifying the capacity of their products.

Ques. What may be said of charging a battery as quickly as possible.

Ans. As a general rule, such a procedure should not be adopted unless the battery be thoroughly discharged.

Ques. What precaution should be taken?

Ans. The danger to be avoided in rapidly charging a cell is its tendency to heat.



Figs. 112 and 113.—Switchboard and motor generator circuit connections for charging a battery from alternating current mains. The connections of a third wire are shown, for use in case a three phase circuit is available.

A battery should never be charged at a high rate unless it be completely exhausted, since it is a fact that the rate of charge that it will absorb is dependent upon the amount of energy already absorbed.

Ques. What apparatus is necessary in charging a battery?

Ans. The battery may be charged from direct current mains having the proper voltage. A current as near uniform as possible is required, and existing conditions must be met in each separate case, it is the rule to use a motor generator set with a regulating switchboard. Such an apparatus

consists of a direct current dynamo, driven direct from the shaft of a motor, which, in turn, is energized by current from the line circuit.

With a direct current on the line, a direct current generator may be used; but with an alternating current an induction motor is required. The speed of the motor is governed by a rheostat, and the output of the dynamo is thus regulated as desired.

Ques. How may a battery be charged through the night without an attendant being present?

Ans. The charging may take place without any attention, if careful estimate of the amount of current required be made, and the rate of charge based on this estimate.

If, say, 72 ampere hours be required to recharge, and the time available is nine hours, the average rate of charge must be 8 amperes.

Assuming a 110 volt circuit, the rate at the start should be about 10 amperes; if from a 500 volt circuit, about 9 amperes; as, in charging from a source with constant voltage, such as a lighting or trolley circuit, the rate into the battery will fall as the charge progresses. This also applies if the charging be done, without attendance, from a mercury arc rectifier.

Ques. What precautions should be taken in charging a battery out of a vehicle?

Ans. When a battery is being overhauled, or out for cleaning, if charged before replacement in the vehicle, the cells must be connected together in series and to the charging source in relatively the same manner as if they were in the vehicle; that is, the positive (+) terminal of one group of cells must be connected to the negative (—) terminal of the next group, and the two free terminals, one positive and the other negative, must be connected respectively to the positive and negative terminals of the charging circuit, but not until all of the groups have been connected in series. **Great care must always be taken to have the polarities correct** and the wire or cable for the connections of ample size to carry, without heating, the heaviest current used in charging.

The size used in the vehicle will be proper. The operation of charging is then carried on in the same manner as if the battery were in the vehicle.

Answers Relating to Battery Troubles, Care and Maintainance

Ques. How is short circuiting within a battery caused?

Ans. It may be caused by some of the active material (if the cell be of the pasted variety) scaling off and dropping between the plates, or by an over collection of sediment in the bottom of the cell.

Ques. How is short circuiting detected?

Ans. A short circuited cell is indicated by the marked difference in color of the plates or of the specific gravity of the electrolyte, as compared with the other cells.

If a foreign substance has become lodged between the plates, it may be removed by a wood or glass instrument.

If some of the active material has scaled off it may be forced down to the bottom of the jar. If excessive sediment be found, the jar and plates should be washed carefully, and re-assembled.

A cell that has been short circuited may be disconnected from the battery and charged and discharged several times separately, which may remedy the trouble.

No particular damage will be caused if the trouble be discovered and removed before these symptoms become too marked.

Ques. How should batteries be treated, when used but occasionally?

Ans. If a battery is not to be used for several days, it should first be fully charged before standing; if it continue idle, a freshening charge should be given every two weeks, continuing the charge when the cells begin to gas freely.

Ques. What action takes place when a battery stands idle for some time?

Ans. It loses part of its charge, due to local losses in the cells.

Ques. What should be done in case of lack of capacity?

Ans. If the current consumption, as shown by the meter, be greater than normal, the vehicle is running "hard," and

Fig. 114.—One cell of the Gould storage battery for electric vehicle use. According to the data given by the manufacturers, this cell, containing four negative and three positive plates, has a normal charging rate of 27 amperes; a distance rate of 22 amperes for four hours; a capacity of 81 ampere-hours at 3 hours discharge, and of 90 ampere-hours at 4 hours discharge. Forty such cells are generally used for an average light vehicle battery.

it should be overhauled. If, however, the current consumption be normal, there may be poor connections or trouble in the battery; there may be a dry cell, due to a leaking jar; some or all of the cells may be in a state of incomplete charge, due to the battery having been run too

low and not sufficiently charged, or the plates may be short circuited, either by the sediment (deposit in the bottom of the jar) getting up to the bottom of the plates or by something that has fallen into the cell.

Ques. How are internal short circuits indicated?

Ans. Short circuits in a cell are indicated by short capacity, low voltage and low specific gravity, excessive heating and evaporation of the electrolyte.

Ques. How are internal short circuits located?

Ans. If the trouble cannot be located by the eye, the battery should be connected in series and discharged at the normal rate through suitable resistance. If a suitable rheostat be not available, a water resistance may be used.

This consists of a receptacle (which must not be of metal) filled with very weak acid solution, or with salt water in which are suspended two metal plates, which are connected by wires through an ammeter. The current may be regulated by altering the distance between the plates, or by varying the strength of the solution. As the discharge progresses, the voltage will gradually decrease, and it should be frequently read at the battery terminals; as soon as it shows a sudden drop, the voltage of each cell should be read with a low reading voltmeter.

While the readings are being taken, the discharge rate should be kept constant and the discharge continued until the majority of the cells read 1.70 volts; those reading less should be noted. The discharge should be followed by a charge until the cells which read 1.70 volts are up, then the low cells should be cut out, examined, and the trouble remedied.

Ques. What causes low specific gravity when there are no short circuits?

Ans. 1, sloppage or a leaky jar (the loss having been replaced with water alone), 2, insufficient charge, 3, over discharge, or 4, a combination of these abuses. Any of these mean that there is acid in combination with the plates, which should be brought out into the electrolyte by a long charge at a quarter of the normal discharge rate.

Ques. How should the low cells be treated?

Ans. They should be grouped by themselves and charged as a separate battery, care being taken that the positive strap of one cell, is connected to the negative strap of the adjoining cell and that the charging connections are properly made. If there be not sufficient resistance in the charging rheostat to reduce the current to the proper point, a water resistance should be used.

While a cell is being treated, when possible, the cover should be removed (if sealed, the compound can be loosened by using a hot putty knife).

Ques. How should cells be disconnected?

Ans. The best method of disconnecting cells assembled with pillar straps, for the purpose of replacing broken jars, cleaning or taking out of commission, is to use a five-eighth inch twist drill, in a carpenter's brace, boring down into the top of the pillar about one-quarter inch; the connector sleeve is then pulled from the pillar. By following this method, all parts may be used again.

When cells are equipped with top straps, the straps should be cut with a sharp knife or chisel midway between the cells.

Ques. When should a battery be taken out of commission?

Ans. When it is to be out of service for several months, and it is not convenient to give it the freshening charge every two weeks.

Ques. Describe the method of taking a battery out of commission.

Ans. The battery is charged in the usual manner, until the specific gravity of the electrolyte of every cell has stopped rising over a period of one hour (if there be any low cells, due to short circuits or other cause, they should be put in condition before the charge is started, so that they will receive the full benefit of it). The cells may now be

disconnected and covers and elements removed from the jars, (if sealed, the compound is loosened with a hot putty knife). The elements are placed on their sides with the plates slightly spread apart at the bottom, the separators withdrawn, and the positive and negative groups pulled apart. The

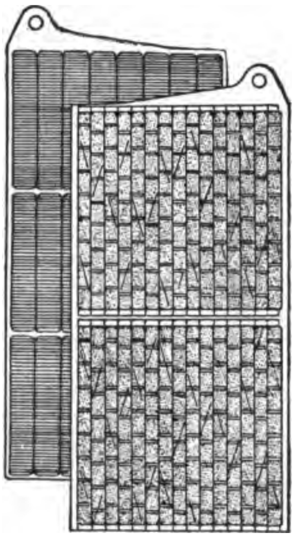


Fig. 115.—Plates of Edison storage battery. The positive or nickel plate consists of one or more perforated steel tubes, heavily nickel plated, filled with alternate layers of nickel hydroxide and pure metallic nickel in excessively thin flakes. The tube is drawn from a perforated ribbon of steel, nickel plated, and has a spiral lapped seam. This tube after being filled with active material is reinforced with eight steel bands, equidistant apart, which prevent the tube expanding away from and breaking contact with its contents. The tubes are flanged at both ends and held in perfect contact with a steel supporting frame or grid made of cold rolled steel, nickel plated. The negative or iron plate consists of a grid of cold rolled steel, nickel plated, holding a number of rectangular pockets filled with powdered iron oxide. These pockets are made up of very finely perforated steel, nickel plated. After the pockets are filled they are inserted in the grid and subjected to great pressure between dies which corrugate the surface of pockets and force them into practically integral contact with the grid.

electrolyte is washed off with a gentle stream of water and the plates allowed to drain and dry. The positive plates are ready to be put away. When dry, the negatives are completely

immersed in electrolyte (of about 1.275 specific gravity), and allowed to soak for three or four hours. The jars may be used for this purpose. After rinsing and drying, they are ready to be put away; wash also the rubber separators.

Wood separators, after having been in service, will not stand much handling and had better be thrown away. If it be thought worth while to keep them, they must be immersed in water or weak electrolyte, and in reassembling, the electrolyte must be

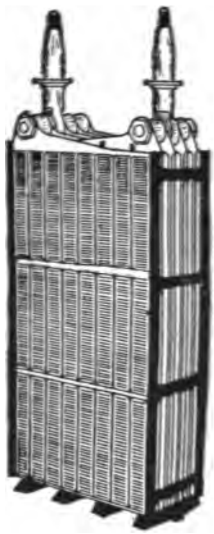


Fig. 116.—Complete element with insulators of Edison storage battery. After the plates are assembled into a complete element, narrow strips of treated hard rubber are inserted between the plates, thereby separating and insulating them from each other. The side insulator is provided with grooves that take the edges of the plates, thereby performing the dual function of separating the plates and insulating the complete element from the steel container. At the ends of the element, that is between the outside negative plates and container, are inserted smooth sheets of hard rubber. At the bottom, the element rests upon a hard rubber rack or bridge, insulating the plates from the bottom of container.

put into the cells immediately, as wet wood separators must not stand exposed to the air.

Ques. What precaution should be taken with the jars?

Ans. They should be thoroughly cleaned with fresh water, no sediment being allowed to remain.

Ques. How should a battery be put in commission?

Ans. It should be treated in the same manner as if it were new, and the regular instructions for assembling and putting into commission a new battery followed.

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1. A battery must always be charged with "direct" current and in the right direction.

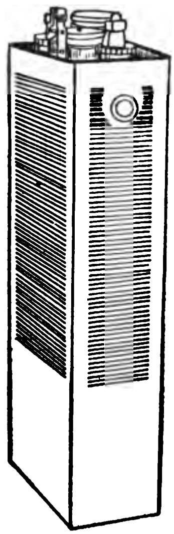

Fig. 117.—Cell of Edison storage battery. The jar or container is of nickel plated sheet steel with welded seams; the walls are corrugated to give strength. The cell cover of sheet steel has four mountings, two being pockets to contain stuffing boxes about the terminal posts. One of the other two is a separator which separates spray from the escaping gas while the battery is charging. The fourth mounting is for filling with electrolyte. The electrolyte consists of a 21% solution of potash in distilled water with a small per cent of lithia. The density of the electrolyte does not change on charge or discharge.

2. Care should be taken to charge at the proper rates and to give the right amount of charge, the battery should not be undercharged or overcharged to an excessive degree.

3. **A naked flame should not be brought near the battery while charging or immediately afterwards.**

4. The battery should not be allowed to overdischarge, or to stand completely discharged.

5. Voltage readings should be taken only when the battery is charging or discharging; if taken when the battery is standing idle they are of little or no value.

6. The battery temperature should not exceed 110° Fahr.

7. The electrolyte should be kept at the proper height above the top of the plates and at the proper specific gravity. Only pure water should be used to replace evaporation. In preparing the electrolyte, **water should never be poured into the acid.**

8. The cells should be kept free from dirt and all foreign substances both solid and liquid.

9. The battery and all connections should be kept clean and all bolted connections tight.

10. If there be lack of capacity in a battery, due to low cells, there should be no delay in locating and bringing them back to condition.

11. Sediment should not be allowed to get to the plates.

Ques. What is a mercury arc rectifier?

Ans. A device for converting alternating current into direct current for use in charging storage batteries.

Ques. Describe the construction and operation of a mercury arc rectifier.

Ans. Fig. 118 is an elementary diagram of connections. The rectifier tube is an exhausted glass vessel in which are two graphite anodes A, A′, and one mercury cathode B. The small starting electrode C is connected to one side of the alternating circuit, through resistance; and by rocking the tube a slight arc is formed, which starts the operation of the rectifier tube. At the instant the terminal H of the

NOTE.—The Edison storage battery is manufactured in five sizes: all are identical in electrical characteristics, and differ only in the number and size of plates and capacity, as follows:

Type	B-2	B-4	A-4	A-6	A-8
Normal Ampere-Hour Output	40	80	150	225	300
Average discharge voltage, per cell	1.2	1.2	1.2	1.2	1.2
Rate of charge, in amperes, for seven hours	7½	15	30	45	60
Normal rate of discharge, amperes	7½	15	30	45	60
Weight, in pounds, of cell complete	4½	7	13½	19½	25½
Average weight in lbs., per cell, assembled in tray	4½	7½	14¼	20	26
Tray dimensions—inches, length—2 cell	..	$6\frac{13}{16}$	7¾	10	$12\frac{13}{16}$
Required height of battery compartment	8½″	8½″	15″	15″	15″

All trays are $6\frac{1}{16}$ inches wide.

supply transformer is positive, the anode A is then positive, and the arc is free to flow between A and B. Following the direction of the arrow still further, the current passes through the battery J, through one-half of the main reactance coil E, and back to the negative terminal G of the transformer. When the impressed E. M. F. falls below a value sufficient to maintain the arc against the counter E. M. F. of the arc and load, the reactance E, which hereto-

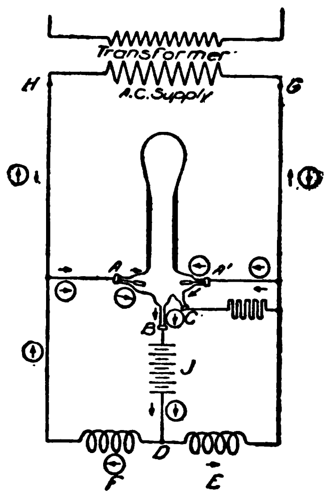

Fig. 118.—Elementary diagram of mercury arc rectifier connections. A, A', graphite anodes; B, mercury cathode; C, small starting electrode; D, battery connection; E and F, reactance coils; G and H, transformer terminals; J, battery.

fore has been charging, now discharges, the discharge current being in the same direction as formerly. This serves to maintain the arc in the rectifier tube until the E. M. F. of the supply has passed through zero, reversed, and built up such a value as to cause the anode A to have a sufficiently positive value to start the arc between it and the cathode B. The discharge circuit of the reactance coil E is

now through the arc A′B instead of through its former circuit. Consequently the arc A′B is now supplied with current, partly from the transformer, and partly from the reactance coil E. The new circuit from the transformer is indicated by the arrows enclosed in circles.

Ques. How is a mercury arc rectifier started?

Ans. A rectifier outfit with its starting devices, etc., is shown in fig. 119. To start the rectifier, close in order named line switch and circuit breaker; hold the starting

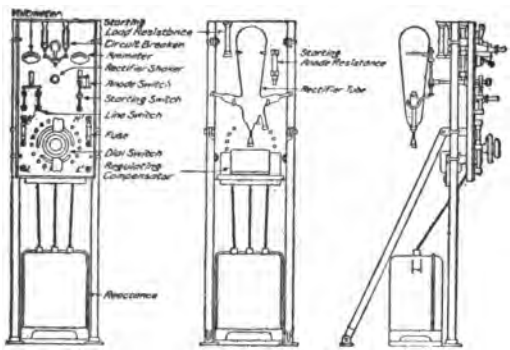

Fig. 119.—Mercury arc rectifier outfit, or charging set. The cut shows front, rear, and side views of the rectifier, illustrating the arrangement on a panel, of the rectifier tube with its connection and operating devices.

switch in opposite position from normal; rock the tube gently by rectifier shaker. When the tube starts, as shown by greenish blue light, release starting switch and see that it goes back to normal position. Adjust the charging current by means of fine regulation switch on the left; or, if not sufficient, by one button of coarse regulation switch on the right. The regulating switch may have to be adjusted occasionally during charge, if it be desired to maintain charging amperes approximately constant.

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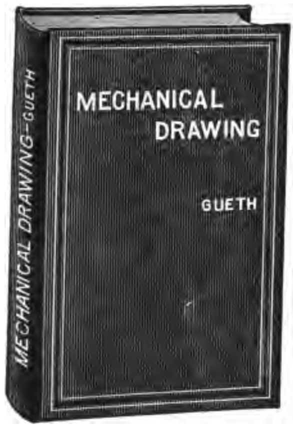

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